SILICON CHIP

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"Dual Core" Picaxes!

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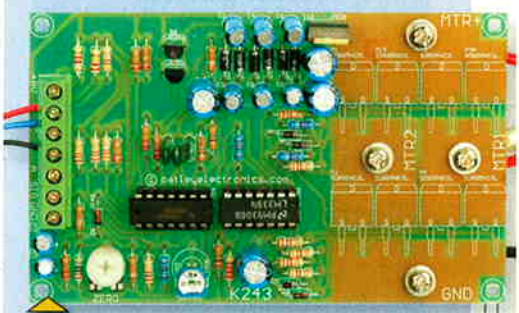

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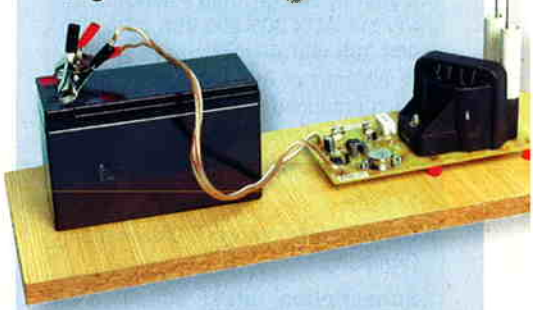

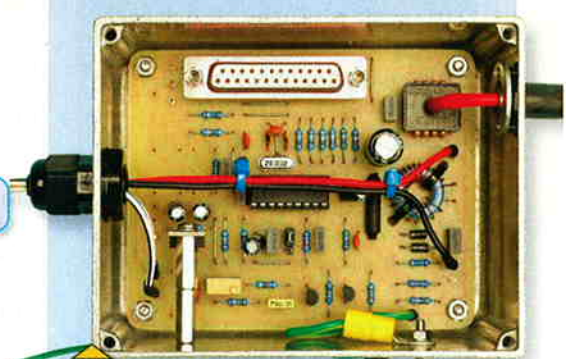

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Publisher's Letter

Banning incandescent lamps will have negligible effect on greenhouse gases

It is about time some logic was brought to bear on this hysteria about global warming.

Even if it is really happening (yes, yes the glaciers are melting but they have been doing so for hundreds of years) and even if some of the warming is caused by human activity, we need to take a measured response. If we assume that a good portion of the current global warming is caused by human activity, what are the major contributors to it? They would seem to be land clearing, coal mining and coal burning and oil consumption in all its forms (mainly for transport).

As far as fossil fuel consumption is concerned, transport and power generation would be the major uses. So if we decide that we must reduce fossil fuel use, we should be looking to more efficient transportation and more efficient power generation as well as increasing renewable energy sources such as solar, wind and hydro electricity. And of course, there is nuclear power generation.

We will also want to make major reductions on the consumption side but this is much harder. So the Federal government's recent announcement of a proposed ban on incandescents seems like desperately wanting to be seen to be "doing something" (see the press release on page 11 of this issue, from Malcolm Turnbull, Minister for the Environment and Water Resources). By the government's own figures, quoted in the press release, its overall effect on Australian greenhouse gas emissions will be tiny, estimated at 800,000 tonnes per annum from 2008 to 2012. Well whoopee.

As a proportion of domestic power consumption, lighting is quite small. If we halve the power used by domestic lighting, it will have very little effect on our overall power bills and by extension, on greenhouse gas emissions. For those that don't already know, the major power use in homes is for heating, cooling and cooking. Any reduction in domestic power use due the proposed ban on incandescent lamps will be easily swamped by the increasing take-up of air-conditioning and plasma TVs.

Another factor to be considered is that most domestic lighting use is at night. That might seem blindingly obvious but the government apparently has not recognised why it might be important. The reason it is important is that most power usage at night is merely using the "spinning reserve" of our base-load power stations. You could switch all the lights off (if that was possible) and the base load power stations would still be spinning away, using just as much coal.

Just as this issue went to press there came the news that Europe was likely to adopt the same measure to ban incandescent lamps. They gave credit to Australia for coming up with the idea. Normally the European community is quite capable of coming up with all sorts of measures to restrict trade, economic activity and freedom but now they are about to adopt a stupid idea from Australia. Wonderful.

I wonder how Italian lighting companies will like the idea. Why should I be concerned about Italy in all of this? It turns out that most of Australia's domestic light fittings (apart from fluorescent battens) come from either Italy or China. That is why we have ended up using such a diverse range of incandescent lamps, including all those Edison screw lamps. Much of that trade is going to be disrupted, isn't it? Many Australian lighting retailers will also find the going pretty difficult too, unless they can quickly source a whole range of new light fittings which are compatible with compact fluorescent lamps. That's just another of Malcolm's unforeseen ramifications.

If governments really want to reduce greenhouse gas emissions they will need to do a lot more hard thinking and develop some real strategies to achieve it.

Leo Simpson

They have arrived

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5 litre and 10 litre fuel cartridges are available. For example, an off-grid video camera will operate for up to 8 weeks on a single 10 litre fuel cartridge.

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Model	600	1200	1600
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  Maintenance free and absolutely reliable. Even under extreme climate conditions it ensures 100% availability of your equipment. This is a decisive advantage, especially in hard-to-reach areas or with critical applications such as observation posts.
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MAILBAG

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Headphone amplifier solution for serious hearing loss

With respect to the item on serious hearing loss on page 101 of the February 2007 issue, I too have a serious hearing loss problem with, effectively, one ear useless and the other cutting off quite sharply at around 5kHz. Combined with severe tinnitus, this leaves me straining to hear dialog from the TV, particularly female voices.

Some moons ago I purchased a Super Ear kit ("Electronics Australia", May 1998) from Jaycar (Cat KA-1809). This has proved to be a boon which provides more than adequate audio HF boost, enabling me to enjoy TV programs with satisfactory resolution of all AF frequencies within the normal speech band. I would recommend this kit to your reader, W. B.

Ernie Blankley,
Brisbane, Qld.

Help with B&W picture tubes

I just could not help but smile when I read the introduction to the Servicemen's Column in December 2006: "Imagine watching a TV that's now 50 years old". I was doing that very thing some two hours earlier on my AWA 21-inch 204T (with the deluxe chassis). So I don't find it unusual. Mine gets a work out at least once a week with either DVDs, tapes or my younger kids who watch ABC cartoons.

The reason I am writing is the intriguing mention of Stephen Appleby and the replacement Thomas picture tube. I was led to believe that Thomas Picture Tubes in Riverwood, Sydney closed down in the late 1980s and the remaining stock of monochrome picture tubes went to the tip.

I have a few pre-1960 television sets which I work at restoring. They take an excessive amount of time and mostly are nearly impossible to get 100% perfect. Unfortunately, my only source of replacement picture tubes and certain other bits is from council clean ups and the problem is that scroungers hunting around for scrap metal rip the backs off these old sets, smash the neck off the picture tube and take the copper deflection yoke.

My question is: can anyone help? Are there any SILICON CHIP readers who have an ancient TV covered in junk in their garage or rotting under their house which is destined to become council clean-up landfill in the Sydney area or surrounds? I don't seem to be able to beat the scrap guys and would love to get to it first.

I've almost got enough 21-inch 90° and 70° tubes (though extras would be welcome) but really need a couple of 17-inch 70° or even 90° types. These have longish necks of about 37mm in diameter with a large multi-pin Bakelite plug. These are physically quite different to the more common shorter 110° types used from around 1959 until the end of black and white TV. If anyone could help I would be most appreciative.

Thanks for all the Vintage Radio columns and the recent historical articles. Please keep them coming.

Owen Kemp,
Phone (02) 9524 0746
ake90071@bigpond.net.au

Comment: there must be quite a few old colour sets which are about to be disposed of, as well. Anyone wanting to restore old colour sets would be wise to act now and collect as many as possible before they all go to council clean-ups.

Excellence in Education Technology Awards

May I express my appreciation to Leo Simpson and the team who produce this excellent magazine every month. The articles are varied and I think there is a good balance between general interest, cutting edge, practical projects and vintage radio. I know there has been some negative comment about valves but I really marvel at what the radio engineers achieved with them before the semiconductor revolution. That's one reason why I appreciate the Vintage Radio section.

My introduction to radio and electronics goes back to 1954, when I built a one-valve set, a "Radio & Hobbies" project of that year. While I have taken a big detour into agriculture for about 30 years, I have come back to really enjoy this hobby in "retirement" and am back again building SILICON CHIP projects and vintage radio restoration. Hopefully, I can encourage some young person to take up similar or more challenging projects.

I was particularly pleased to see the article on Page 57 of the February 2007 issue, concerning the "Excellence in Education Technology Awards" to two HSC students, Matt McDonald and Lauren Capel. The choice of these two winners shows the learning value of widely differing electronics projects chosen by these two young people and the encouragement in this field by Leo Simpson and the SILICON CHIP staff. Congratulations!

Richard Wood,
Loxton, SA.

Ultrasonic Eavesdropper and ANABAT

I got to the end of the Ultrasonic Eavesdropper article in the August 2006 issue to find that you only talked about it being used as a direct listening device.

Why not connect it to a computer running ANABAT software? This

Radio broadcasts for the blind at sporting events

Recently, I was listening to the cricket on ABC radio when an idea came to me. They were interviewing a fellow who (I think) is the boss of Blind and Visually Impaired Cricket in Australia. He's blind himself and was talking about his love of going to regular cricket matches but he lamented that it's rare for a match to be broadcast on the radio. His point was that while he gets the atmosphere from being at the game, it's the ABC radio commentary that *takes* a blind person to the game.

This got me thinking that there must be hundreds of thousands of visually impaired people around Australia who would love to attend sporting and other events but need more than the normal PA system to tell them what's happening. They need the information they aren't able to read, can't see and which most of us take for granted.

I wonder how hard it would be to set up a national system of local broadcasting for visually impaired people (and anyone else who would appreciate it). I guess it could be AM or FM but FM is probably as good as any because of the capture effect. If possible, find a standard, single frequency in the broadcast band so that anyone, anywhere in the country would know where to listen.

The "broadcasts" would be done by volunteers. It would have to be coordinated so you don't have a double up at any one event but this should be easy to do via a central body (website). The gear would be relatively inexpensive to produce and I guess the ERP could be limited to legal levels.

Once such a service takes off, there's no reason why it couldn't be extended to places such as shopping malls, tourist attractions and so on.

Paul Zucker,
via email.

would make the project more useful and of wider practical value. ANABAT displays the call patterns of bats and identifies them and was apparently designed for bat census taking.

To find out more, got to **www.titley.com.au/tanabat.htm**

Pete Hutton,
Glen Waverley, Vic.

Comment: thanks for your reference to the ANABAT system. We had not heard of it. However, we doubt that our Eavesdropper circuit would be compatible with ANABAT software because their system uses different frequency division ratios and uses a zero crossing method to derive a digital version of the signal for software analysis.

Microwave oven transformer can be rewound

I like your magazine in most cases, however the recent article on what to throw away from a microwave oven (SILICON CHIP, December 2006) really got me. You said to chuck the transformer!

That's the most useful part of the whole thing. You cut out the high voltage secondary and rewind it with thicker wire and you have the basis for heavy-duty battery charger. Any low voltage can be obtained, depending on the number of secondary turns.

I know you don't like telling dummies to play mains games but this is an exception, surely!

Lester Hendershot,
via email.

Comment: you are correct, of course. However, we would not recommend this to anyone not experienced in rewinding mains power transformers.

Hospital electronics requires technical backup (1)

Your January 2007 Publisher's Letter prompted me to write. It is rare that anybody notices much in a hospital other than the front line doctors and nurses. I don't mean to detract from the great work they do, however as a Biomedical Engineer, recently retired after 30 years in a major public hospital, it is heartening to see our work being noticed (even if it is by "one of us" so to speak).

Biomedical (or clinical) engineers and technicians look after the vast array of equipment used for patient care in modern hospitals. Inventories

Atmel's AVR, from JED in Australia

JED has designed a range of single board computers and modules as a way of using the AVR without SMT board design

The AVR570 module (above) is a way of using an ATmega128 CPU on a user base board without having to lay out the intricate, surface-mounted surrounds of the CPU, and then having to manufacture your board on an SMT robot line. Instead you simply layout a square for four 0.1" spaced socket strips and plug in our pre-tested module. The module has the crystal, resetter, AVR-ISP programming header (and an optional JTAG ICE pad), as well as programming signal switching. For a little extra, we load a DS1305 RTC, crystal and Li battery underneath, which uses SPI and port G.

See JED's www site for a datasheet.

AVR573 Single Board Computer

This board uses the AVR570 module and adds 20 An./Dig. inputs, 12 FET outputs, LCD/Kbd, 2xRS232, 1xRS485, 1-Wire, power reg. etc. See www.jedmicro.com.au/avr.htm

$330 PC-PROM Programmer

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Also available is a multi-PROM UV eraser with timer, and a 32/32 PLCC converter.

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Mailbag: continued

Microcontroller projects not lightweight

I note that in the February 2007 Mailbag pages of SILICON CHIP, Ian Farquar lists the Programmable Christmas Star as an example of the sort of "lightweight" project that he would prefer to see less of. More than 100 constructors would perhaps disagree, several of whom have provided very positive feedback.

I don't claim that the Christmas Star was in the class of those complex projects of yore that Ian praised. But what's not apparent is that the PIC assembler source code ran to more than 1000 lines – a very far cry from the 20 lines of PICaxe code that Ian mentioned. And it took months to write (albeit part-time).

And that ties in with the point I was making my letter that you also printed in February. Much of the true complexity of microcontroller-based electronics is hidden in the (quite extensive) firmware. You rightly give the Digital Volume Control as a counter-example of a project requiring a lot of development. Yet it looks deceptively simple – "essentially a 2-chip solution", as the project description puts it. Again, a low parts count does not necessarily imply a lack of developmental complexity.

I say keep up the good work!

David Meiklejohn,
via email.

Comment: you make a very good point about microcontroller projects. For example, the software for the Programmable Ignition project currently featured in SILICON CHIP is the most complex we have developed to date. The final assembler line tally totals some 6020 lines required to perform all the functions and features required of the programmable ignition. It took many months to write and debug and represents a substantial investment in R&D.

run into many thousands of items and tens of millions of dollars in value. Most of the equipment is electronic based but many items, such as patient ventilators and dialysis machines, are mechanically complex.

The work is exacting and interesting. Much of the equipment is used for life support or making patient treatment decisions. Routine and breakdown maintenance must be carried out with great care and a clinical understanding of the purpose of the equipment is essential for troubleshooting.

The complexity of modern computer-driven equipment, particularly in the operating theatre and intensive care, often requires technical staff to support the nurses and doctors using the equipment. This may be in the form of training or troubleshooting, or working alongside the clinicians in the ICUs and theatres.

I suppose the greatest reward in the job is knowing the value of the work you are doing – contributing to patient care – and I would encourage qualified technicians and engineers to consider a career in this field. Just contact the Biomedical (or Clinical) Engineering Department of a major hospital. Good committed staff are in demand!

John Symonds,
Sydney. NSW.

Hospital electronics requires technical backup (2)

It was great to hear of Leo Simpson's appreciation of the vast array of "biomedical" or "electromedical" equipment on his recent visit to hospital.

I am a Biomedical Engineer and look after the service, repair and maintenance of all the biomedical equipment you described in your article. I work with a small team of engineers that look after Eastern Health, a network of hospitals in the Eastern suburbs of Melbourne – see **www.easternhealth.org.au.**

The "drip machine" is known as an infusion pump. They are commonly used for the controlled delivery of fluids and drugs to patients. There are other pumps know as PCA (Patient Controlled Anaesthesia) pumps which have a hand control that allow the patient to request a "shot" of morphine or pethadine when they are in pain. All these devices have a vast array of hardware and software safeguards that prevent over delivery of drugs and protect the patient in case of failure.

The vast array of biomedical equipment that was used during Leo's time at hospital would not work as well if it were not for the team of biomedical engineers servicing and maintaining the equipment in the background. Most biomedical equipment requires annual service to check electrical safety and calibration and to replace commonly worn parts.

Simon Cowley,
Ringwood East, Vic.

Nuclear power reactors could be greatly improved

I enjoyed reading the "Publisher's Letter in the February 2007 issue of SILICON CHIP. I would like to comment in the following way. I am not necessarily a promoter of nuclear energy as the best way to minimise global warming. In some cases (China) it is worth consideration. But if one is to examine its prospects, the best implementations of this technology should be considered. I refer to an article in Scientific American for December 2005: "Smarter Use of Nuclear Waste" by William H. Hannum, Gerald E. Marsh and George S. Stanford.

This article described the advanced liquid metal reactor (ALMR) cycle as in advanced fast neutron integrated reactors. This technology has been demonstrated successfully in a prototype reactor prior to 1994. The main points are:

(1) For a given equal energy output, this reactor produces less than 1% of the radioactive waste that a conventional reactor produces.

(2) The radioactive waste that this reactor produces is less radioactive in 200 years than the waste from a conventional reactor would be in 100,000 years.

(3) This reactor can be fuelled with the radioactive waste from conventional reactors and/or decommissioned nuclear weapons.

(4) Reprocessing of fuel rods takes place in the same building complex that the reactor is in.

(5) This reactor is "passive safe". While operating, its cooling system can be

turned off and it will not melt down. (6) Because of the high efficiency of this reactor, known uranium ore reserves would serve our energy needs for many thousands of years.

G. Calhoun,
via email.

Comment: AMLR sounds very attractive but it may be many years before commercial designs exist. This is especially the case since research into the prototype IFR (Integral Fast Reactor) which incorporated the AMLR concept, was discontinued by the US government in 1994, only three years before completion. This was a seriously misguided decision, similar to the US move to kill off their electric car industry just a few years ago.

Plugpack mayhem

The Mailbag letters by Ross Herbert and Graeme Dennes in the October and December 2006 issues of SILICON CHIP respectively raised issues with plugpacks. It seems that the plugpack situation is very untidy if not bordering on mayhem. Perhaps one could stand back and take a broader view.

Our houses are supplied with alternating current. AC power is appropriate for efficient transfer of bulk electrical power over long distances and for meeting the needs of high power domestic devices such as electric ovens, toasters, air conditioners, etc but not so appropriate for modern domestic electronics.

In the last 30 years or so, domestic and office electronic equipment has trended towards lower power and internal DC voltages, as witnessed by the variety of voltages output by plugpacks. Laptop computers are a special case that require from 15-18V DC at up to 8A!

A solution to managing this changed load type could be to install properly engineered DC distribution systems in homes and businesses. This DC system would not replace the current 240VAC system but be installed in addition. Appropriately designed electronic equipment would simply use a cable to plug in to the DC system with no plugpack or internal AC section required! An appropriate distribution voltage might be 24V DC (or a combination of 12V and 24V) to match current battery technology.

In simple form, the DC distribution system could be fed directly from the AC system through rectifiers. However, real benefits accrue if the DC system is coupled with a system containing substantial energy storage (most likely a lead/acid battery bank under current technology). The battery bank would act as a power supply buffer and AC system power spikes and brownouts would not be such a hazard to sensitive equipment.

There are further gains if the energy is derived from a non-polluting source such as a solar array. Solar systems would match a DC distribution system beautifully and are now well developed. A typical domestic solar system providing 13kWh/day out of a total daily load of 25kWh/day has been reported in the media.

Advances are being made in areas such as solar cells efficiency and high-intensity LED lighting. Once the DC distribution system became established, it is likely more loads would switch to DC; eg, house lighting. Mass production would tend to lower installation costs with time and development of such systems would be directly transferable to developing countries where AC supplies are problematic.

Implementing a DC distribution system would not require particularly novel or new technology but would require development of standards and hardware. Additionally, manufacturers would need to be encouraged to modify their designs to accommodate standard voltages.

So maybe there is a solution to plugpack mayhem, which may also provide significant greenhouse gas savings, but implementing such a concept is more of a political challenge than it is a technical issue.

Bruce Fischer,
Giralang, ACT.

Information on Geiger counters

In the February 2007 issue of SILICON CHIP, I saw the request from B. B. for information about a Ratec brand Geiger Counter. I can help!

As a geophysicist working in mineral exploration, I'm familiar with the now outdated Geiger counters (also known as ratemeters) once used for

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Mailbag: continued

Car Speedos can be wrong while odometer is correct

I read with interest Jack Chomley's letter in the February 2007 issue regarding his speedo experience. In 1995 I purchased a 1991 Volvo 240 wagon, which comes fitted with a VDO speedo with electronic pickup, a stepper motor odometer and a 270° needle analog speedo display.

I soon realised there was a calibration problem, even though I have all standard equipment and tyres. I made many tests; using speedometer check zones, advisory radar installations and lots of kilometre peg and stopwatch observations during long distance cruising trips in places like the Northern Territory.

What is amazing is that when I read Jack's article, I felt like he had stolen my data, as my results were identical to his! My odometer is correct to within 100m over 10km, while my speedo indicates 108-109km/h for an actual road speed of 100km/h. An indicated 100km/h gives an actual road speed of 92km/h.

My (less than ideal) solution was to fit a VDO Speed Alert unit calibrated to the correct reading and rely on it rather than the speedo when cruising. However, it is still inconvenient having to mentally convert every time I look down at the speedo.

I also noted Jack's mention of the relaxing of the accuracy requirements of the Australian Design Rules. Meanwhile, our technically illiterate legislators and law interpreters keep trying to reduce the allowable tolerances for radar speed checks to less than the tolerance of the equipment fitted to our cars.

Dave Heap,
Armidale, NSW.

Comment: we suspect that this big discrepancy between odometer and speedometer has been present in cars for a very long time. After all, there is a specific requirement about odometer accuracy yet car reviewers have been complaining about optimistic speedos for decades. It will probably require the successful challenging of speed fines because of inaccurate speedos before the situation changes.

uranium exploration. I don't actually have a circuit for the Ratec instrument mentioned but I do have several old geophysics texts (1940-50s) that describe the technology and provide circuits for battery-valve instruments. These show that the Geiger tube needs about 400V DC for operation.

Also, the well-known book "Fortunes in Minerals" by Ion Idriess (1951) (available from most antiquarian book dealers) gives a detailed description on using the Geiger counter and provides the circuit for the instrument built by the Australian Bureau of Mineral Resources.

In particular, one other I have – "Prospecting and Mining for Uranium in Australia – Notes for the Guidance of Prospectors", published in September 1954 by the Australian Atomic Energy Commission and Department of National Development, gives quite detailed instructions for building 2-valve and 3-valve portable instruments. Again, 400V seems to be the voltage needed for the Geiger tube. In addition, it lists all the commercially built instruments available in Australia in April 1954 and the Ratec instrument is mentioned (with the approximate purchase price of 70.00 pounds) from Medical Equipment Services Pty Ltd, 79 Collins St, Melbourne. A search of the internet shows that this company still exists in Melbourne as a supplier of medical electronics:

http://www.mesaustralia.com.au/

Maybe B. B. could contact them directly for information about his Raytec 115F Geiger-Muller counter.

For further information, I would recommend that B. B. visit the library of his State Mines Department and look for other (Australian or State) government publications of that era concerning uranium exploration, as they too are likely to have further information about these instruments, and may even describe the Ratec instrument. In particular, try the library at Geoscience Australia (previously Bureau o f Mineral Resources until 1990, then called Australian Geological Survey Organisation – AGSO, now Geoscience Australia) in Canberra – the biggest earth science library in Australia.

Stephen Mudge,
Nedlands, WA.

Comment: thanks for that information. We liked your mention of Ion Idriess. He was a great Australian writer whose works have long disappeared from library shelves.

Bike Computer Ampere Hour Meter

I was very interested to see Stan Swan's article about using cheap bike computer plus a PICAXE micro as a DC ampere-hour meter (SILICON CHIP, February 2007) as I had been wanting such a device for my electric power-assisted bicycle.

Generally, I ride for exercise but have a number of large hills near my home and these are difficult at my age. My solution was to purchase an electric conversion kit for my 26-inch bike. It is a 200W hub motor mounted in the front wheel with a 24V NiMh battery and speed controller. My problem is knowing if I have enough battery capacity left to get up my hill at home after a long ride.

I was able to use Stan's circuit but with a 0.01Ω resistor in place of the 1Ω resistor in the battery negative line to measure the current. The resistor was made from about 35mm of heavy nichrome wire from my junk box and carries a maximum current of 20A. The low value of resistor was chosen to minimise voltage drop to the motor.

I found I needed to set the bike computer for a 500mm diameter wheel to get a high enough pulse rate to measure low currents. Only one line of the program had to be modified for calibration. By trial and error w2=2500/w1 came out right compared to a digital multimeter.

The bike computer speedo indicates amps and the distance then shows ampere-hours directly. This was my first venture using a PICAXE which I found easy to use and understand.

Bevan Walls,
Saratoga, NSW.

SURPLUS ELECTRONIC COMPONENTS

40MHz-550MHz CATV Amplifier

Device: MHW6181
Vin:+70dBmV
Freq: 40MHz-550MHz
Gp: 18.2dB
Package: 714-04
Vcc: 28Vdc
Manuf.: MOTOROLA

$8.00 ea

#35697

500V 16A Triac (Pk-10)

Device: BT139-500
Volts: 500V
Amps: 16A
IGT: 35mA (min)
Package: TO-220

$5.00 Per Pack of 10

#35680

Low Dropout Pos. Regulator

Desc.: **LM2931AT-5.0**
Function: Low Dropout Pos. Voltage Regulator
Rating: +5V
Package: TO-220

$1.00 ea

#10326

100V 6A PNP Transistor (Pk-10)

Device: **TIP42C**
Ptot:65W
Package: TO-220

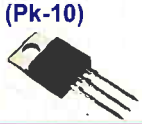
#35625

$5.00 Per Pack of 10

60V 2A NPN Darlington (Pk-10)

Device: TIP110
Pd: 50W
Package: TO-220

#35624



$3.00 Per Pack of 10

350MHz 60V 2A Darl. Transistor (Pk-10)

Device: **BSR50**
Polarity:NPN
Ptot:.8
Package: TO-92

$3.00 Per Pack of 10

#26720

40V 0.6A PNP Transistor (Pk-100)

Device: **PN2907A**
Polarity:PNP
Ptot:0.4W
Package: TO-92

$4.00 Per Pack of 100

#35692

NPN 2GHz SMD RF Transistor (Pk-100)

Device: **2SC5508-T2**
Polarity:NPN
Vceo:3.3V
Ic:35mA
Pt: 115mW
Package: 4P Mini Mold

$6.00 Per Pack of 100

#35300 NEC

65V 100mA 250mW Transistor(Pk-100)

Device:BC856B
Polarity:PNP
Case: SOT-23
* RoHS Compliant

$2.00 Per Pack of 100

#35717

100nF 50V Y5V 20% SMD 1206 (Pk-100)

Desc: SMD CAPACITOR
Tol: 20%

$2.00 Per Pack of 100

#32131

Low Noise Precision Op Amp

Device:OP27EZ **#35651**
Function:Low Noise Precision Op Amp
Vos:10V
Package:DIP-8
* For Data See Web **

$1.00

Solder (500gm)

Weight: 500gm
Type: 63/37
Flux RMA: 2%
Manuf. AIM
Made in CANADA

$8.00

#35710 0.75mm **#35713** 1.25mm
#35712 1.0mm **#35714** 1.5mm

2.5µF 400VAC Class C Motor Start Cap

Device:PAR45025P
Value:2.5µF
Volts:400/450VAC Class C/Class D
Connection: 6.3mm Tab
Mount. End Bolt (M8 Stud)
Size(LDmm):58.5 x 30
Manuf:Lifasa

$2.00

#35280

PCB Mom. Push Switches(pk marked 0-9)

Marked with numbers (0,1,2,3,4,5,6,7,8,9) = 1 set
Type: SPST N/O Momentay
Pitch: 2.54mm (0.1")
Size: 19 x 19mm
Heigth: 10.5mm

$2.00 PK

#35698

5-Digit 230V AC Counter

Counts every time power is switched
Rating: 230VAC @ 3700 Ohm
Size: 35 x 40 x 67mm
Made in Japan **#35684**

$3.00

Dual Attenuator

With LED indicator
Mid/High range for 3 way systems
Impedance: 8 ohm
Power: 18 Watts
Arista: LA5 **#35685**

$3.00

STD. 0.9mm Soder Wick.

Length: 5ft

$2.00

#13474 80-1-5 White

8-Pin Valve Socket

This unit is moulded from high grade thermo setting resin.The pins are adequately plated and have deep solder terminals, sufficient for several hard wiring points per pin. Sturdy flange mount is meant for fitting above the chassis. **#35654**

$3.00

3 Way Plugable Euro-Style Terminal (Pk-10)

Type: 3 Way Stackable
Rating:300VAC 10A
Spacing: 5mm
Inc.3 Way PCB Strip **#35707**

$3.00 Per Pack of 10

63A 240VAC Mini Din Circuit Breaker

Device:V87382
Function:Circuit Breaker
Rating:240VAC 63A
Mounting:Mini Din
Manu:TERASAKI

$5.00

#35709

4.7GB 4x Speed Blank DVD-R (Pk-10)

Single Sided DVD-R
Size:4.7GB
10 per Spindle
Manuf: EMTEC

$3.50

#35683

Battery Free Small Hand Powered Torch

* Just Shake for Power
* No batteries needed
* Size: 165 x 32 (dia)mm
* Super bright LED
* Transparent ABS body

$3.50

#35715

6P6C Modular Crimping Tool

Desc.: Steel construction modular connector crimping tool. Double as a handy cutter or splicer.
Suits 6 position 4 or 6 contact modular plugs.

$12.00

#35716

2200µF 80V 85° Radial Electrolytic Cap.

Value: 2200µF
Volts: 80V
Type: Radial
Size: 25.5(D) x 42(L)mm
Temp: 85°
Lead Spacing: 12.5mmsc. Solder

$1.00

#29258

Flame Retardent ABS Cabinet

Device:1591CBK
Description:Plastic Enclosure
Colour:Black
Size(LBHmm):120x80x38
Manu:HAMMOND
** For PDF see web **

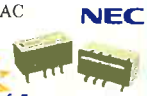
#35009

$3.00

Miniature 3VDC SMD Relay (Pk-5)

Device:UD2-3NUN-L
Contacts:1A @30VDC 3A @125AC
Coil Volts: 3VDC
Action: DPDT
Coil Res.: 64.3 Ohm
Manuf: NEC
* For Data See Web ***

NEC



$4.00 Per Pack of 5

#35303

5-Pin Mini SMD USB Type B Recept. (Pk-10)

Contacts: Phosphor Bronze
Current Rating: 0.5A
Contact Resisitance: 50m Ohm max
Size: 8 x 4 x 9mm
* Data Sheet Available

$5.00 Per Pack of 10

#30544

32.768KHz Crystal (Pk-10)

Freq.: 32.768K
Package: HC-38U
Lead spacing. 1mm

$3.00 Per Pack of 10

#26005

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The proposed ban on incandescent lamps . . .

What will it mean?

In February 2007, Malcolm Turnbull, Federal Minister for the Environment and Water Resources, announced that incandescent light bulbs would be phased out and replaced by more efficient lights such as the compact fluorescent light. Superficially, it seems like a good idea but closer examination shows that there would be substantial drawbacks.

There is no denying that Malcolm Turnbull is a very clever man. He was the co-founder of Ozemail, a successful barrister and merchant banker and now a prominent member of Federal parliament.

But that does not make him infallible and particularly not with regard to decisions involving electrical and electronic equipment. We think he has been badly advised.

Yes, incandescent light bulbs are inefficient when compared to fluorescent lights and other forms of lighting. As a corollary of that, they pump out a lot of heat for the amount of light that they produce.

And yes, typical compact fluorescent light (CFL) bulbs produce about five times the light output of an equivalent incandescent bulb. Under ideal conditions, they can also last somewhere between four and 10 times longer than incandescent lamps and therefore can lead to substantial energy savings.

The trouble is, ideal conditions do not occur very often in household use. For a start, depending on ambient temperature, a CFL takes about 10 to 15 minutes to reach full brilliance. So while they come on as soon as you throw the switch, their initial light output can be quite weak and can have a tendency to flicker as well. If you install a CFL in a toilet or bathroom you may find that they are seldom on long enough to get to full brilliance.

By LEO SIMPSON

Some very ambitious claims are made for life on CFLs. For example, a GE 15W unit in our office at the time of writing claims 8000 hours on the packet while a range of CFLs made by Mirabella claims 15000 hours.

In our experience, these are very ambitious figures and are probably longer than you could expect from a typical 36W fluorescent tube. After all, at 10 hours a day, 15,000 hours is equivalent to an operating life of over four years. Not only that, by the time 15,000 hours rolled around, a typical 36W tube would be a pale tube indeed.

CFLs certainly do not last as long as conventional fluorescent tubes and the reduction in light output is

proportionately greater as they age. A 15W CFL may be equivalent to a 75W incandescent when new but after several thousand hours its light output will be quite weak, if indeed it has survived for that long.

In fact, the only practical applications for CFLs are where they are in use every day for several hours at a time. If you operate them under those conditions, particularly where they are used in applications such as stair wells and external lighting for home units (ie, on for long periods at a time), they can easily last for around 8000 hours or more.

But if you use them in other domestic applications, their life can be shortened drastically, to the point where they often do not last as long as the much-maligned incandescent. The reason they don't last well where they are used for frequent short periods is that they simply don't work well with short start/stop cycles.

The tube phosphor becomes blackened and the tube becomes much harder to start or the complex electronic driver circuit simply fails. As you can see from the description in the separate panel, a CFL circuit may use up to 30 components and these are highly stressed, operate at high temperatures and are subject to severe temperature cycling if frequently switched on and off.

Other drawbacks

If you take a look at the packet for any CFL, you should see warnings about suitability. Specifically, they are not suitable for use with electronic dimmers. In fact, they don't work at all with dimmers. Any warranty will be void if they have been used with a dimmer.

Nor are they suitable for use with any electronic switch or remote control, sensor lights or with timers. The last two are significant because that is an acknowledgement by the manufacturers that CFLs do not last well when switched on or off frequently or at short time intervals.

Heat, cold and vibration

CFLs cannot be used in any application where they get hot. They need plenty of air circulation around them. They cannot be used in recessed light fittings or in table lamp fittings where they are closely confined or poorly ventilated. That rules out a lot of lamp fittings, including oysters (ceiling) and those which include a glass tube within another glass housing. Nor can they be used in ovens, microwave ovens or refrigerators. Why not refrigerators? Because CFLs and standard fluorescent lamps, for that matter, will not work in the cold; they simply refuse to start.

And since CFLs have lots of internal electronic components they don't like vibration either. That means that they should not be used inside garage door openers, vacuum cleaners or combined light/exhaust fans in bathrooms.

There is also a substantial environ-

MEDIA RELEASE

The Hon Malcolm Turnbull MP

Australian Minister for the Environment and Water Resources

T11/07

20 February 2007

World first!

Australia slashes greenhouse gases from inefficient lighting

In a world first move, the Australian Government is taking action to phase out inefficient light bulbs.

The step, announced today at Double Bay Public School by Minister for the Environment and Water Resources, Malcolm Turnbull MP, should reduce Australia's greenhouse gas emissions by 4 million tonnes by 2012.

The reduction in emissions will increase as the phase out progresses and the annual average reduction between 2008-2012 is estimated at around 800,000 tonnes. However, by 2015 the annual cut in emissions will have soared to an estimated 4 million tonnes per annum. Household lighting costs can be reduced by up to 66 per cent.

"The most effective and immediate way we can reduce greenhouse gas emissions is by using energy more efficiently," Mr Turnbull said.

"Electric lighting is a vital part of our lives; globally it generates emissions equal to 70 per cent of those from all the world's passenger vehicles."

"But it is still very inefficient. We have been using incandescent light bulbs for 125 years and up to 90 per cent of the energy each light bulb uses is wasted, mainly as heat."

"A normal light bulb is too hot to hold – that heat is wasted and globally represents millions of tonnes of CO2 that needn't have been emitted into the atmosphere if we had used more efficient forms of lighting."

"These more efficient lights, such as the compact fluorescent light bulb, use around 20 per cent of the electricity to produce the same amount of light."

"A compact fluorescent light bulb can last between 4 and 10 times longer than the average incandescent light bulb, which can lead to major savings in household energy costs."

"While they may be more expensive to buy up front, they can pay for themselves in lower power bills within a year."

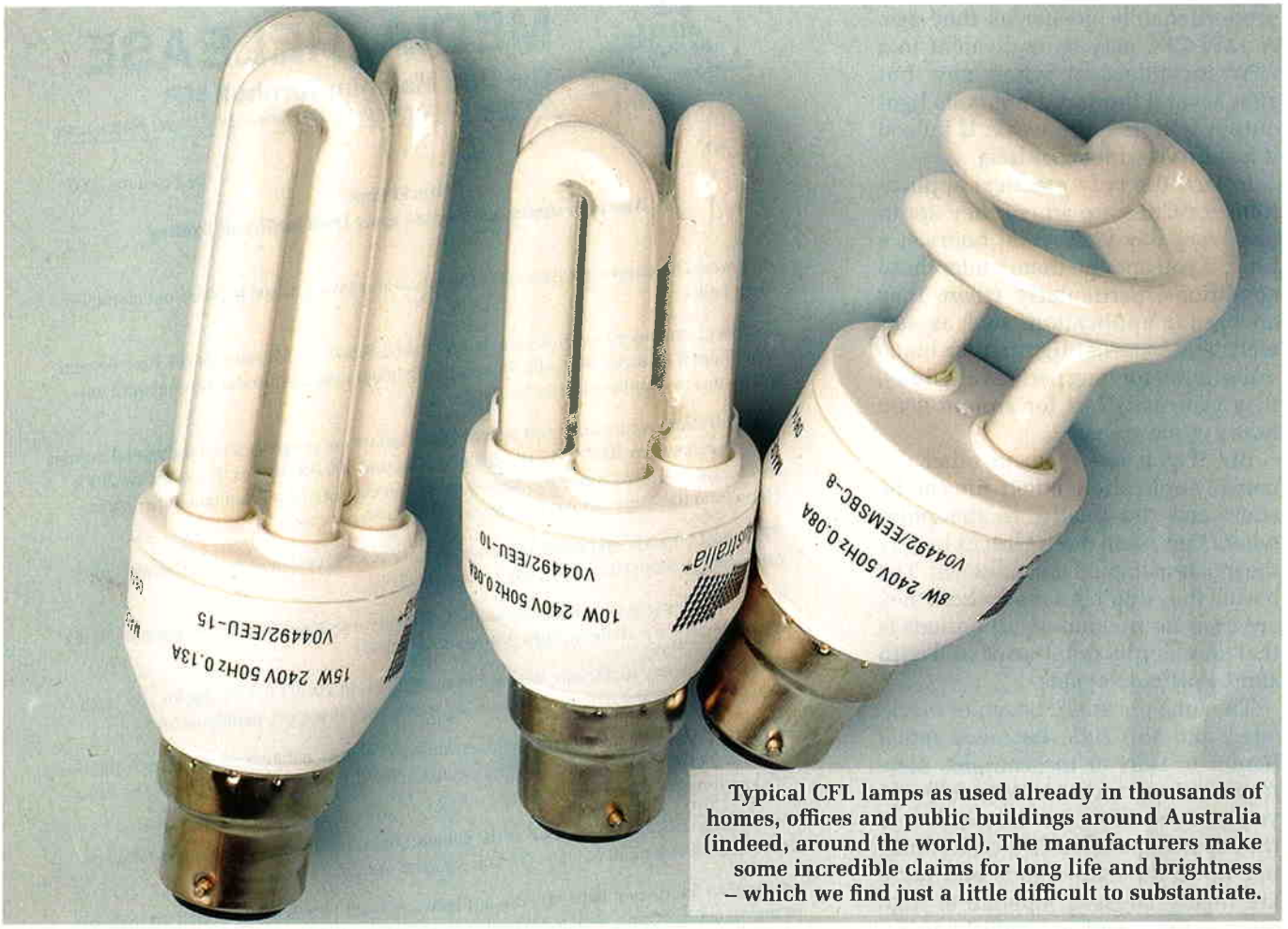
In Australia, lighting currently represents around 12 per cent of greenhouse gas emissions from households, and around 25 per cent of emissions from the commercial sector.

Working with its state and territory counterparts, the Australian Government will gradually phase out all inefficient light bulbs and is aiming for full enforcement of new lighting standards legislation by 2009 to 2010. Special needs areas, such as medical lighting and oven lights, will be taken into consideration.

The Government will also work with the world's largest manufacturers of light bulbs, including China, to broaden the benefits beyond Australia.

"The International Energy Agency has estimated that if all countries made the global switch to compact fluorescent lights that by 2030, annually it would save energy equivalent to more than 5 years of Australia's current electricity consumption," Mr Turnbull said.

"The climate change challenge is a global one. I encourage other countries to follow Australia's lead and make the switch to more energy efficient products like compact fluorescent light bulbs."



Typical CFL lamps as used already in thousands of homes, offices and public buildings around Australia (indeed, around the world). The manufacturers make some incredible claims for long life and brightness – which we find just a little difficult to substantiate.

mental drawback: mercury. All fluorescent tubes contain a small amount of mercury and CFLs are no different. The mercury is there because that is what sustains the electrical discharge in the tube once it is fired. When the tube fires, the mercury is vapourised by the high voltage across the ends of the tube and the resulting electrical discharge produces intense ultraviolet light. This irradiates the white phosphor coating on the inside of the tube and it "fluoresces" to produce visible light.

The amount of mercury inside a CFL is small, typically 4 to 5mg. While it is inside the tube, it is perfectly safe. But once the tube is broken or crushed, as will ultimately happen, the mercury will be released into the environment.

With millions of CFLs likely to be disposed of every year, that amounts to a lot of mercury going into the environment.

Electrical interference

CFLs can cause two forms of interference, electrical and infrared. Part of the electrical interference is inherent in any fluorescent or vapour discharge tube. The high voltage discharge radiates interference over a wide frequency range, up to 10MHz or more and can interfere with radio reception on the broadcast and shortwave bands. The interference from conventional fluorescent tubes is modulated at 100Hz, giving a rough buzzing sound in an AM broadcast radio. But interference from a typical CFL is worse because it is modulated by the high frequency inverter used to drive the tube. So whereas a fluorescent tube might cause a buzzing sound on weak stations in the broadcast band, CFLs can completely obliterate reception in rural areas.

While the discharge inside fluorescents and CFLs is mainly ultraviolet, they also produce heat (infrared) and this is also modulated by twice the driving frequency. So a typical fluorescent light produces heat (you can easily feel it) modulated at 100Hz. A CFL also produces heat (they get quite hot) modulated by twice the inverter frequency. This modulation can typically be at around 20-30kHz but can be in the slightly higher frequency range used by typical infrared remote controls. So if you have a CFL in the same room as your TV or hifi system, the infrared remote control may not work at all – its signal will be completely blanketed by the modulated infrared from the CFL.

By the way, in some CFLs, you can actually hear the whistle from the inverter/electronic ballast. Whether this is a sub-harmonic or because the operating frequency is low is not clear but some people will find it objectionable.

Huge range of incandescents

So far this article must seem pretty negative concerning CFLs. We have harped on about short life, reliability, heat, cold, vibration, interference and so on. What other problem could there possibly be with a general changeover from incandescent lamps to CFLs? The biggest problem of all is simply the huge range of currently available incandescent lamps.

In my own home I can count at least

They haven't really thought this one through, have they? This photo by no means shows the full range of incandescent lamps currently in use (eg, how about all the high intensity halogen floodlights out there) – but the only incandescent lamps that CFLs can now replace are the standard-sized BC and ES general lighting types.

10 different styles of incandescent bulb. In addition to the standard-sized bayonet cap (BS) and Edison screw (ES) bulbs, there are fancy round, candle and twisted candle, in miniature BC and ES, as well standard bases, large round (100mm and larger), double-ended lamps for lighting bathroom mirrors and cabinets, miniature incandescents for sewing machines and so on. Then there are 100W and 150W ES reflector lamps used in outdoor security lights. Where does it all end? Most of these "non-standard" incandescent lamps will never be duplicated in CFL, particularly the smaller ones.

If you want to see the scope of the problem, just visit your local lighting retailer or a branch of Bunnings. The range of available lamps is astounding.

Even if CFLs can fit in place of incandescents in many light fittings, they may still not be suitable because of their longer form factor – they may simple poke out of a fitting rather than be fully housed.

Some light fittings do not suit CFLs because of their different light output distribution. For example, most CFLs have little light output on their longitudinal axis.

With the best will in the world, we cannot see too many people being happy with a 24-lamp chandelier fitted out with CFLs!

And what about 240VAC double-ended halogen lamps used in higher-powered exterior lighting used around homes and commercial buildings?

In truth, we do not yet know the scope of this proposed ban or phase-out of incandescent lamps because the announcement released by Malcolm Turnbull (reproduced elsewhere in this article) is quite general in tone, with no specific details or timetable.

But if the aim is to phase out inefficient incandescent lamps, what about 12V halogens used in such large numbers in modern homes? These are a real drain on Australia's electricity grid, both in homes and retail showrooms where their numbers are so great that they substantially increase the air-conditioning load. Mind you, if 12V halogens were to be banned, a great many homes and shops would require substantial rewiring and all new lamp fittings, unless reasonably effective LED equivalents become readily available. Existing LED equivalents are expensive and not as bright as halogens.

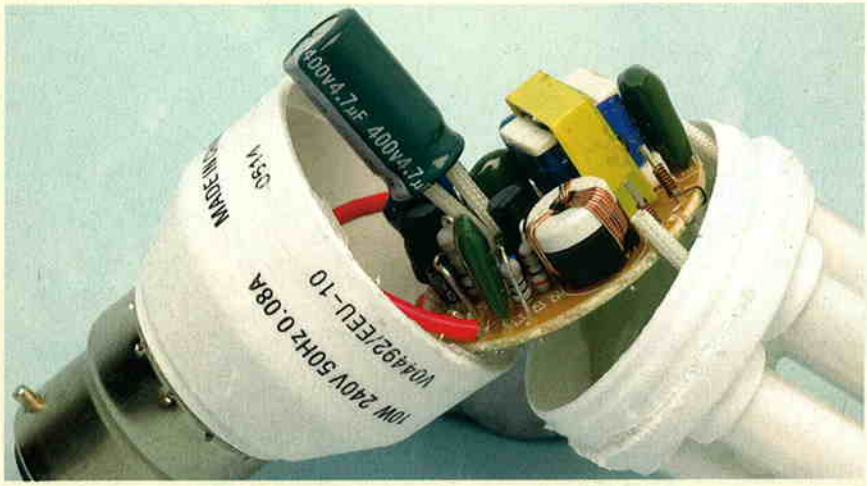
Ultimately, if the proposed ban is to be all encompassing, a large proportion of home-owners are going to be very unhappy when they realise the full implications.

Finally, if you don't accept our word on the above disadvantages and drawbacks of CFLs, just go to **http://www.gelighting.com/na/business_lighting/faqs/cfl.htm**

This is a list of frequently asked questions (FAQs) on CFLs on General Electric's Consumer & Industrial Lighting website. Note that GE do have a dimmable CFL available in the USA but we have not seen a version of it on sale in Australia.

Will the whole idea of phasing out incandescents be quietly shelved after the next Federal election? We think that is a strong possibility. If not, you had better stock up on the more unusual incandescents in your home.

How CFLs work



This photo shows the internal circuitry of a current model CFL used in a recent promotion by Sydney's major electricity distributor, Energy Australia. The two Mosfets are tiny, in TO-92 encapsulation. The 4.7μF main DC filter capacitor can be clearly seen. It is this capacitor which is the component most at risk from high temperatures.

The operation of a compact fluorescent lamp (CFL) is rather more complex than the simple resistive element of an incandescent lamp.

The circuit above is for a typical compact CFL operating at 240VAC. Note that this is a general description of CFL circuit operation. Actual circuits vary widely from brand to brand and model to model but the broad principle of operation is much the same.

It uses a bridge rectifier in series with a small inductor (L1) and 47Ω resistor together with diode D1 and capacitor C1, to develop around 340V DC.

The rectifier in American CFLs (operating from 110V) uses a voltage doubler on the input instead of a bridge rectifier.

The 340V DC is fed to the rest of the circuit which functions as an inverter and ballast.

In effect, what happens is that the circuit operates in two separate modes, one to start the tube and the second mode for normal running.

Two Mosfets (Q1 & Q2), transformer T1 and a number of associated components make up an oscillator or inverter. The fluorescent tube is driven via inductor L2 and winding N1 of the transformer. T1 also drives the gates of Q1 & Q2 via windings N2 & N3 which are connected in antiphase.

Tube starting

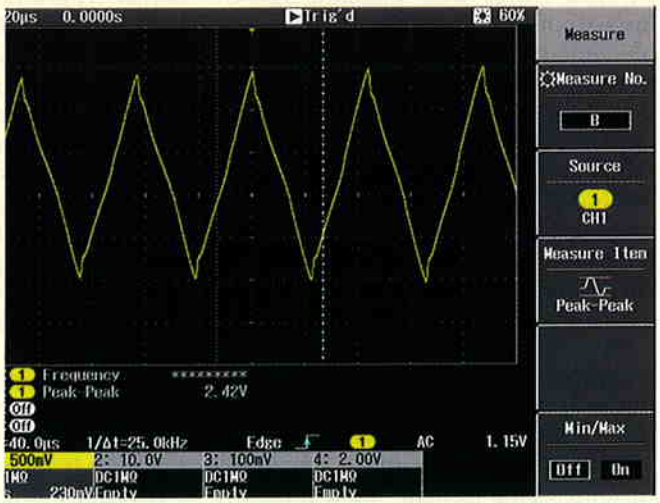
When power is first applied, the 2.2nF capacitor connected to Diac 1 charges via the 560kΩ resistor. When the voltage reaches about 30V, the Diac fires (breaks down) and discharges the capacitor into the gate of Q2. Zener diode ZD2 protects the gate from over-voltage.

Mosfet Q2 is now switched on and current flows from the positive supply via the 47nF capacitor, the fluorescent tube top filament, the 3.3nF capacitor, the second tube filament, inductor L2 and transformer T1's N1 winding. This current flow in N1 then applies gate drive to Q1 via N2 and switches off gate drive to Q2 via N3 due to the antiphase connection of this winding.

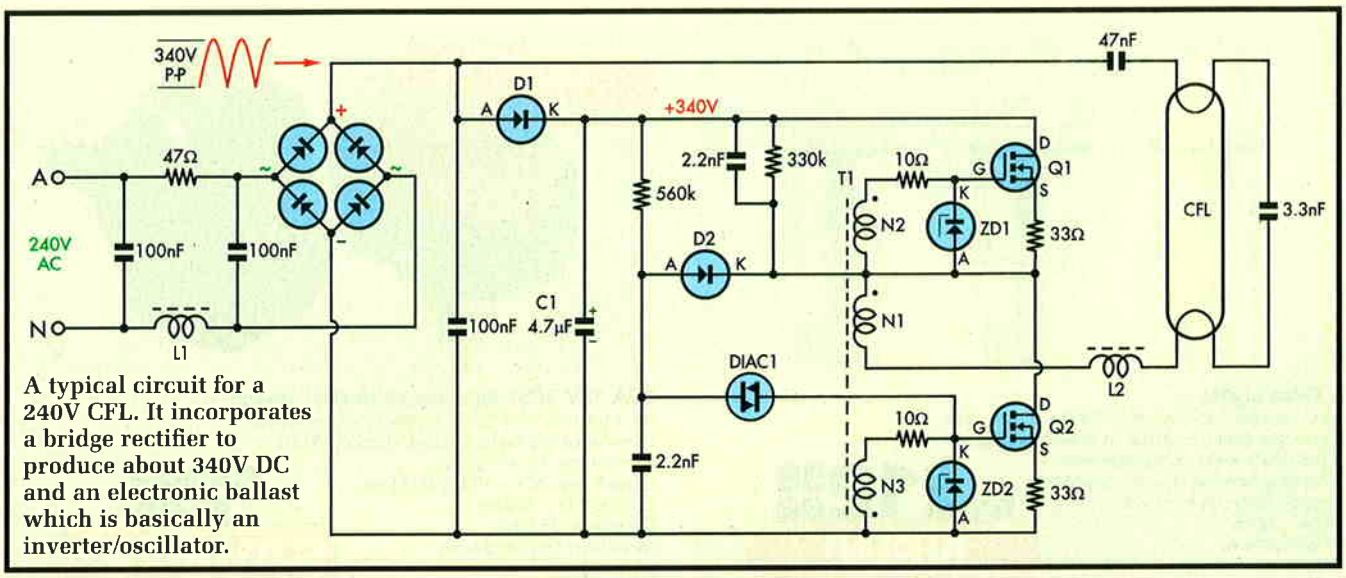
If oscillation doesn't occur, the process starts all over again with the 2.2nF capacitor charging again to fire the Diac to turn on Q2. When oscillation does occur, Mosfets Q1 and Q2 rapidly switch on and off in alternate fashion. The frequency of operation is set by the combined inductance of L2 and the N1 winding, together with the 3.3nF capacitor across the tube.

The startup circuit comprising the 2.2nF capacitor and the Diac is now prevented from operating by diode D2. This diode

Taken with a short antenna in close proximity to CFLs, these scope screen shots demonstrate the RF interference modulation. In this scope shot, we see a 22kHz carrier modulated by 100Hz. The 22kHz is the inverter frequency of the CFL ballast circuit while the 100Hz is a product of the bridge rectifier and 50Hz 240VAC mains supply.



Here we see the same CFL waveform running at a higher timebase frequency to show its roughly sawtooth waveform.



A typical circuit for a 240V CFL. It incorporates a bridge rectifier to produce about 340V DC and an electronic ballast which is basically an inverter/oscillator.

discharges the 2.2nF capacitor every time Q2 is switched on.

The oscillator current now flows through the filaments of the fluorescent tube and allows the normal mercury discharge to take place.

This means that the fluorescent tube will light up. When this happens, the 3.3nF capacitor is effectively shunted by the mercury discharge and the voltage across the tube is now about 100V peak.

Normal running

The frequency of oscillation is now determined by the properties of the core used for transformer T1.

As the current builds up in winding N1, the core begins to saturate. When this happens, the flux in the core stops changing and gate drive to Q1 or Q2 ceases. The flux now collapses to drive the opposite Mosfet and this process continues to maintain oscillation. The current through the tube is limited by the current at which T1's core saturates and by L2's inductance.

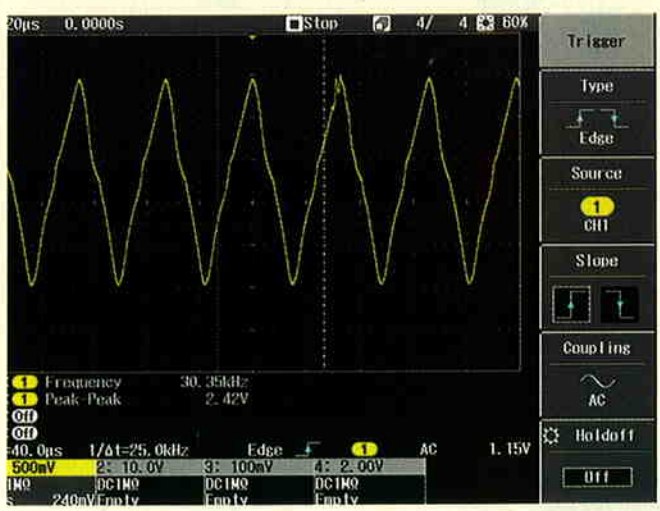
The two 10Ω resistors, together with zener diodes ZD1 & ZD2, limit the gate drive to Q1 & Q2, while the 2.2nF capacitor at the cathode of D2 forms a snubber network to suppress commutation in the opposing Mosfet at switch on. This considerably reduces the switching losses in each Mosfet.

The 330kΩ resistor in parallel with this capacitor keeps diode D1 reverse biased at start-up.

Finally, the 4.7nF capacitor in series with one of the tube filaments ensures that the tube is driven by AC. This prevents mercury migration to the tube ends which would cause blackening and shorten the tube life.

SC

The scope shot above, from another CFL, shows a 30.75kHz waveform modulated at 100Hz while the scope shot at right shows the same waveform at higher timebase speed (20µs/div) to show its sawtooth shape.



None of these waveforms reveal the modulated broadband RF noise radiated by CFLs but this is easily demonstrated if you operate a standard AM broadcast band radio in close proximity to any CFL.

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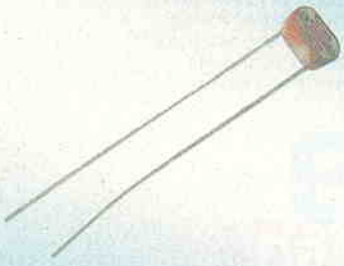

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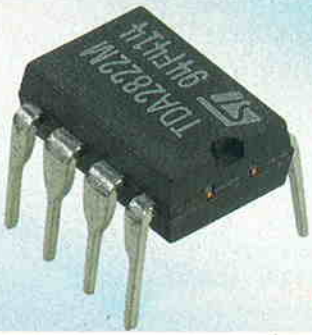

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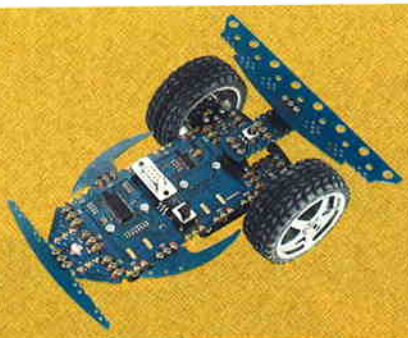

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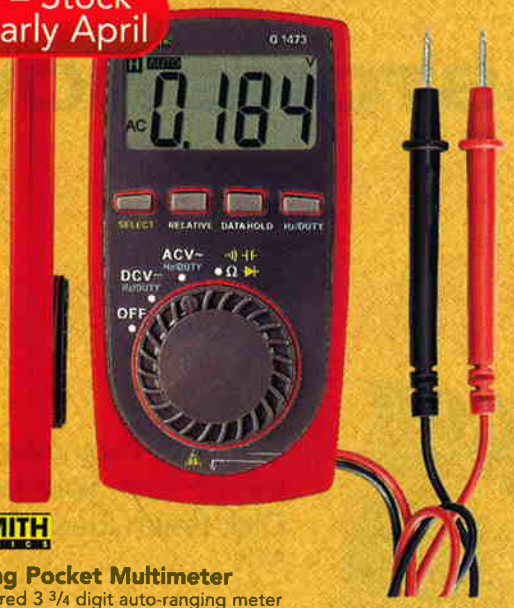

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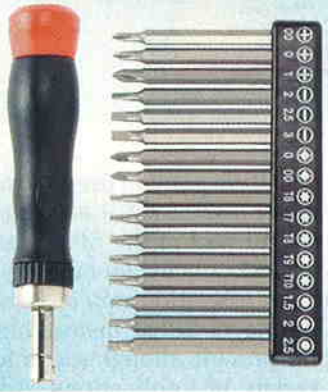

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Introducing the SPLat CC16

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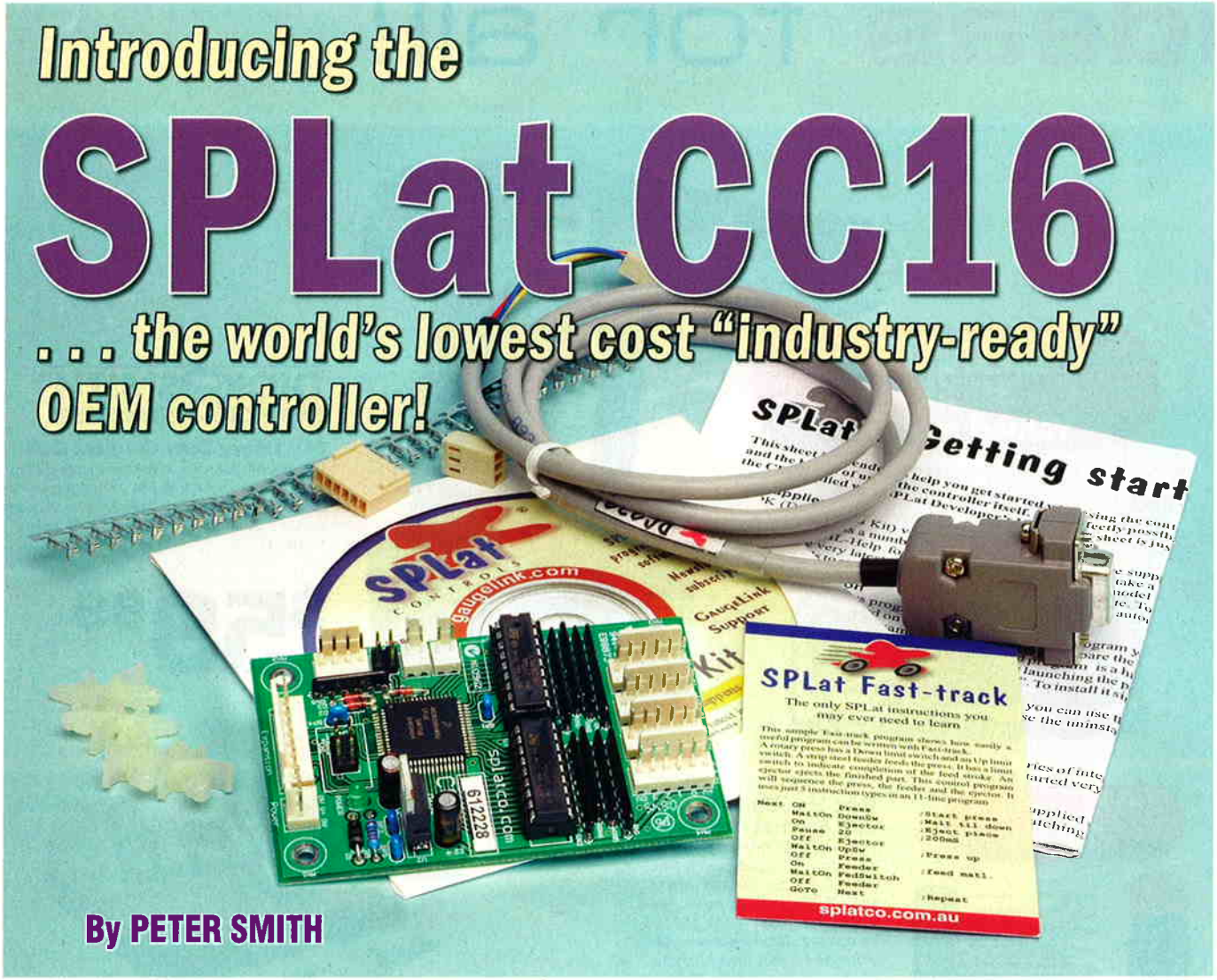


By PETER SMITH

SPLat Controls, an Australian company that produces a range of home-grown industrial-strength controllers, recently added the credit-card sized 'CC16' to their line-up. This new controller sells for less than $100 yet includes many of the features of SPLat's more sophisticated controllers.

THE CC16 BOASTS 16 digital input/output (I/O) lines. All inputs feature over-voltage protection and are designed to work with industrial style "NPN" type sensors. The outputs are capable of sinking up to 400mA and can directly drive solenoids, contactors and small stepper motors – so for many applications, no additional interfacing circuits are required.

Like all SPLat controllers, the CC16 utilises a proprietary programming language. Unlike other controllers that use C, BASIC or ladder logic, the SPLat language was designed from the ground up for industrial control and is therefore exceptionally easy to use. While it is possible to create rudimentary programs in minutes using a subset of the SPLat language called "Fast-track", much more sophisticated control functions can also be built that include maths, state machines, heuristics and look-up tables.

A major selling point of the controller is its multi-tasking abilities, which are an integral part of the SPLat language. Up to 32 concurrent tasks coupled with an execution rate of about 15,000 high-level SPLat instructions per second provide enough scope for a wide variety of applications. Add to that the large program memory (approx. 12,000 instructions) and it's hard to imagine a job that these little devices couldn't tackle!

SPLat's claim that their programming language is the "easiest in the world" for embedded OEM applications piqued our curiosity. While it might be easy for an experienced programmer to use, how would someone with no programming experience fare?

To learn more, we obtained a CC16-DK Developer's Kit which includes the CC16 controller, a CD-ROM with PC software and technical information, a

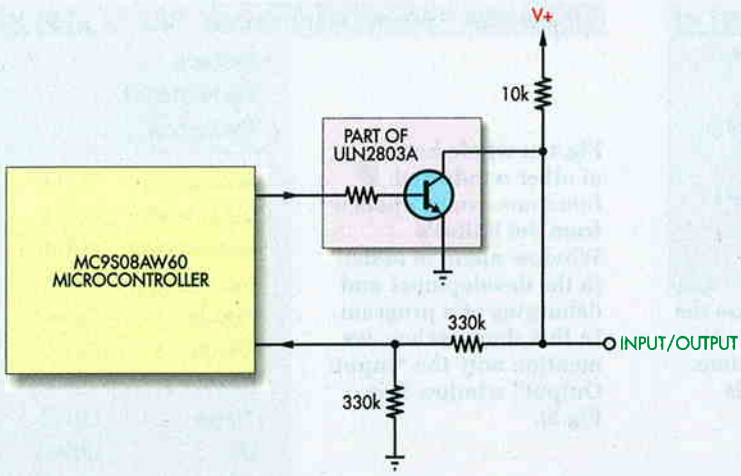


Fig.1: the CC16 features 16 digital input/output (I/O) lines. Here's the basic structure of a single I/O line, showing how one input and one output are connected together and brought out to a single point. Each output is capable of sinking up to 400mA, made possible by ULN2803A high-voltage Darlington driver ICs. When used as inputs, 330kΩ resistors divide the applied voltage by two. The 330kΩ series resistor also limits current flow in the micro's internal protection diodes to provide over-voltage protection. A logic low is specified as 0-3V on an input and a logic high as 7-32V. For those interested, the complete schematic can be downloaded from www.splatco.com.au – look in "Outline drawings & other files" under the "Support" section.

serial cable and five friction lock connectors for I/O and power hook-up. A power supply is not included in the kit but a plugpack or any DC supply that can provide 10-24V will work.

Getting started

The first step is to install the Windows-based development software, "SPLat/PC". While we installed ours from the CD, it is also available for free download from **www.splatco.com.au**. The software provides a means of entering and testing your SPLat programs and includes a comprehensive help system.

The serial cable mentioned earlier connects the CC16 to a free serial port on your PC, allowing SPLat/PC to communicate with the controller for debugging and programming. USB-to-serial adapters are available separately if your system lacks the necessary port.

Once testing is complete, a couple of keystrokes see a "tokenised" version of your program uploaded to the flash-based memory in the CC16's on-board microcontroller. The controller is then ready for use and can be disconnected from the PC.

Note: for the technically curious, the microcontroller embedded in all SPLat controllers is factory programmed with run-time firmware that interprets and executes your tokenised program. This means that your program is not compiled to machine code; rather, it is converted to a "shorthand" language (and all comments stripped away) to conserve space in the micro's Flash memory. SPLat provide free updates to the on-board firmware as new features are implemented. A simple system called "reFlash" is used to apply the updates to all later model controllers, including the CC16.

When SPLat/PC is first launched, a message appears encouraging you to follow a "mini-tutorial". This tutorial describes the basics of the system and gives a rudimentary, hands-on programming example. Let's look at a few of the simple examples given in the tutorial to get an idea of how the SPLat programming system works.

Programming

The Editor window opens immediately when SPLat/PC is started (see Fig.2). This window functions as a basic text editor, where you enter and edit your SPLat program. It also acts as the central control point for all other functions. From within this window, you can write your programs, test them and then download them to the CC16 controller.

The program shown in Fig.2 makes use of SPLat's simplified Fast-track instruction subset. It waits for *input 0* to turn on (go to a logic "low" level) and then turns on *output 5*. It then waits for *input 0* to turn off (go high) again before turning *output 5* off and then looping back to the start.

Having entered this simple program, we can then download it directly to the controller and check if it works as intended. However, unlike this ridiculously simple example, most real programs will have a few problems and will not operate as expected without "debugging".

This is where the real power of SPLat's development environment comes in. We can step through our program one line at a time, get it to stop at any line we desire or run it uninterrupted to help track down any anomalies (Fig.3).

To see the state of the outputs, it's just a matter of opening the Input/Output window from the toolbar (Fig.4). This window (Fig.5) gives a graphical representation of the state of each output line in the form of a graphical "LED".

The Input/Output window also includes a graphical "switch" for each input line, allowing the state of any input to be viewed and altered with just a mouse click – so it's easy to simulate a real switch on any of the controller's input lines. This enables you to test and debug your program without even having the real-word sensors or switches wired to the controller!

Fig.2: SPLat/PC's Editor window looks a lot like Windows Notepad and works in a similar fashion. Here we've typed in a very simple program (borrowed from the mini-tutorial) using just a few instructions from the Fast-Track instruction subset. The operation of the program is largely self-explanatory (see text).

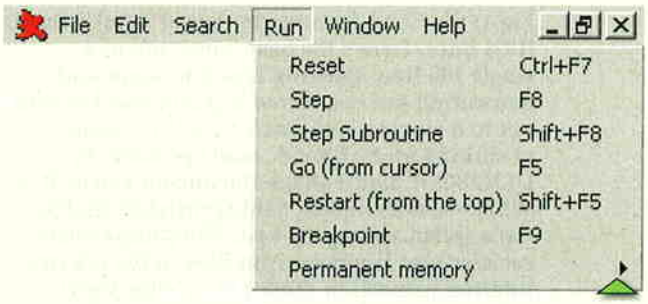


Fig.3: once you've entered your program, you can use the debugging functions on the Run menu to pause execution at a particular line or to step through one line at a time. This makes it much easier to track down bugs and is invaluable as a training aid.

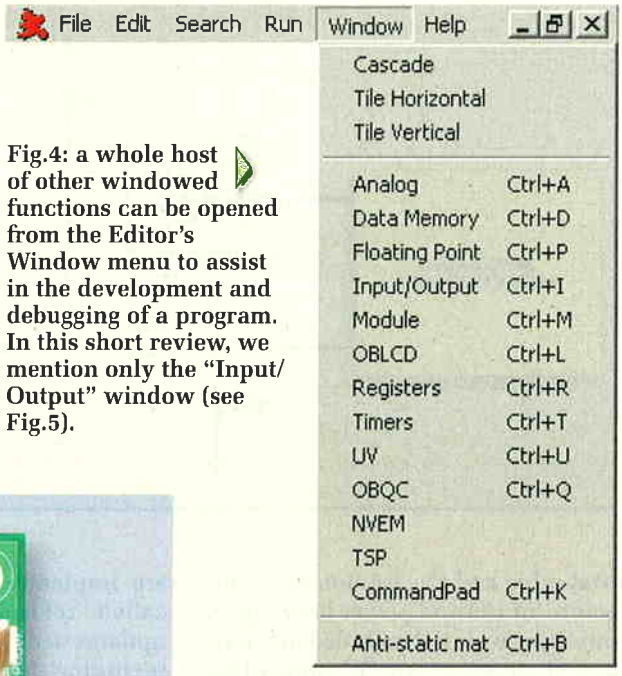
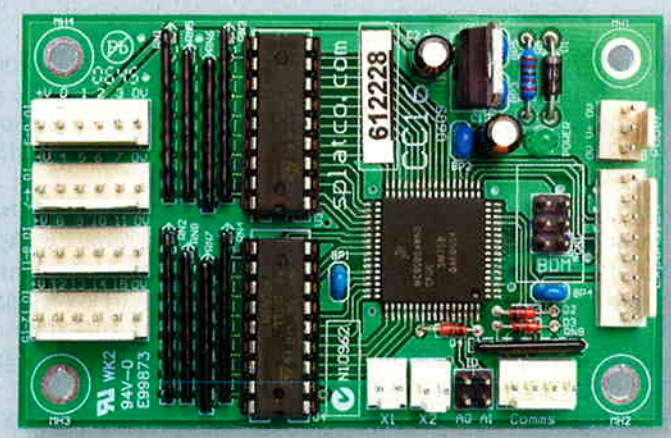


Fig.4: a whole host of other windowed functions can be opened from the Editor's Window menu to assist in the development and debugging of a program. In this short review, we mention only the "Input/Output" window (see Fig.5).



A 64-pin MC9S08AW60 surface-mounted microcontroller IC (the small square black device) accounts for the vast majority of the CC16's operation. All connections to the board are made via friction lock connectors on a 2.54mm pitch. The four 6-way connectors on the left side each carry four I/O lines, power and ground. The 3, 4 and 8-way connectors at the right and bottom sides provide for power input, serial communications and I/O expansion, respectively.

As you've probably gathered by now, SPLat/PC simulates the entire operation of the controller; you don't even need to have the CC16 connected to test your program! However, if it is connected, the controller acts as a "dumb" I/O device. This means that input/output instructions executed in SPLat/PC act indirectly on the controller's port lines (albeit slower than in real time), allowing in-situ testing and debugging.

Using just 14 instructions that make up Fast-track (see Table 1), we've no doubt that just about anyone could write a rudimentary SPLat program in short order. And once you've got those down pat (or if you're already a programming expert), you'll be able to build up your repertoire from some 400 instructions that make up the complete instruction set!

Multi-tasking

Multitasking is a common requirement in industrial automation, so it makes sense to build support for this right into the programming language. SPLat's integrated multi-tasking capabilities are called "MultiTrack" and are almost as easy to use as Fast-track!

Remember our programming example from Fig.2? Imagine for a moment that this simple section of code controls a bottle capper on an assembly line. What changes might be required to drive a multi-headed capper, where each head operates asynchronously?

Believe it or not, the necessary program is barely more complicated than the original, once we've added a few MultiTrack instructions – see Fig.6. Moreover, the program is easily expanded to handle many more channels or other "simultaneous" tasks.

Don't be fooled by the simplicity of our example. MultiTrack can be used to build sophisticated routines with inter-task communication and multiple 24-bit timers, with the latter limited only be available memory space. MultiTrack also provides a useful framework for libraries of common functions. According to SPLat, sample library style programs will be available in the future for a range of common functions.

Expansion

If your application demands more than 16 I/O lines, the CC16 is easily expanded via its SPI-like serial bus. SPLat offers a range of compatible 8-bit and 16-bit expansion boards, one of which features eight heavy-duty 20A relays and eight optically isolated inputs.

Additionally, the CC16 supports the industry standard Modbus protocol and can act as a Modbus RTU slave. Presumably, this would function over the TTL level "Comms" interface, as the low-cost CC16 doesn't include an RS232 interface.

Check it out

As mentioned earlier, SPLat/PC

Table 1: Fast-Track Instruction Set

WaitOn *i*	Wait for input *i* to turn on
WaitOff *i*	Wait for input *i* to turn off
WaitOnT *i,tttt*	Wait for input *i* to turn on, timeout after *tttt* x 10ms
WaitOff *i,tttt*	Wait for input *i* to turn off, timeout after *tttt* x 10ms
GoTo *line*	Go to *line*
GoIfT *line*	Go to *line* if the expected input did occur in the preceding WaitOnT or WaitOffT instruction
GoIfF *line*	Go to *line* if the preceding WaitOnT or WaitOffT timed out
Pause *tttt*	Pause the program *tttt* x 10ms
On *o*	Turn on output *o*
Off *o*	Turn off output *o*
SetMem *m,cc*	Set memory location *m* to value *cc*
DecMGoIfNZ *m,line*	Decrement memory location *m*, go to *line* if the result is not equal to zero
GoIfInOn *i,line*	Go to *line* if input *i* is on
GoIfInOff *i,line*	Go to *line* if input *i* is off

simulates the controller in software, so you can use simple code examples to learn more about the system even without a controller attached. Note that as the same software drives all of SPLat's controllers, you must first specify the controller that you wish to simulate. This is done via the *File -> Configure -> Board Type* menu in the Editor; simply choose "CC16" from the drop-down list.

The on-line mini-tutorials (accessible from the Help menu) are definitely worth a look too – they'll have you writing your own code in less than a couple of hours! SPLat/PC can be downloaded from **www.splatco.com.au**.

Special offer

Until 31st May 2007, SPlat Controls are offering a very special deal for SILICON CHIP readers interested in purchasing the CC16 development kit. To find out more, check out this "special offer" web address: **www.splat-sc.com**.

SPLat Controls design, manufacture and support their products in Australia. They are situated in Seaford, Victoria and can be contacted on (03) 9773 5082. SC

Fig.5: the Input/Output window indicates the status of all of the CC16's output lines using graphical "LEDs" and inputs using graphical "slide switches". Any input can be simulated as high or low by altering the respective switch position with a mouse click. Inputs can also be momentarily set (simulating a pushbutton switch) by simultaneously holding down the Shift key.

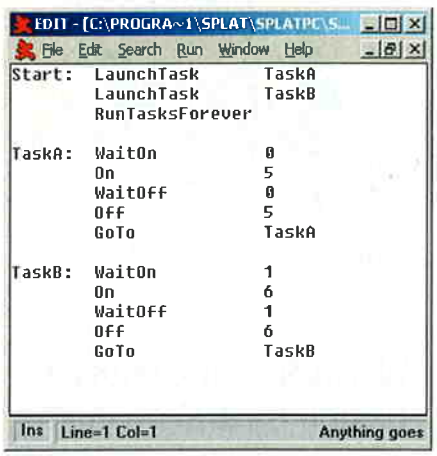
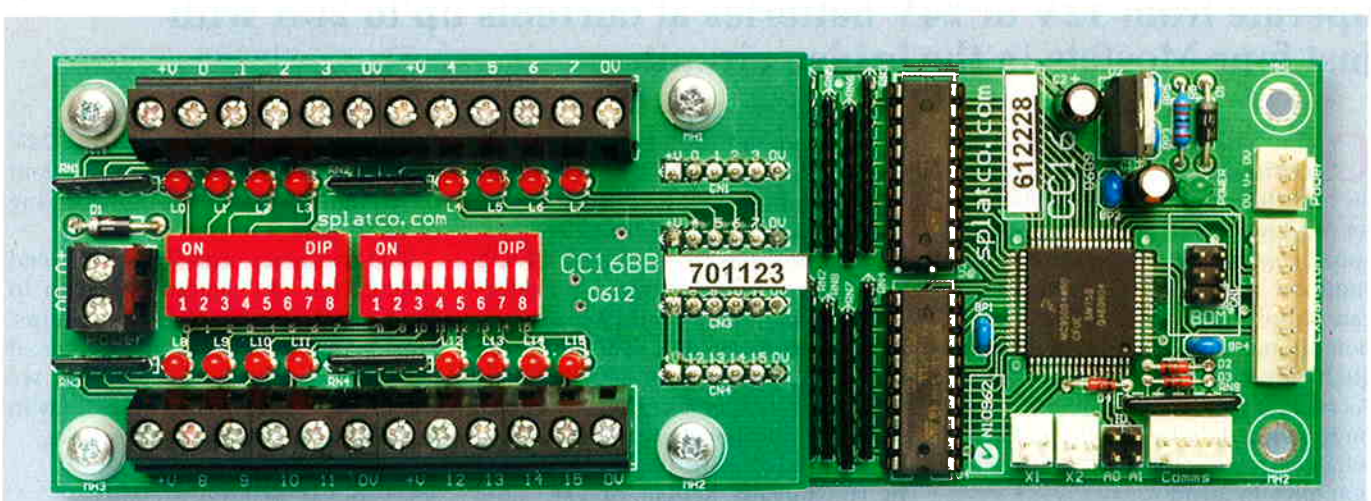
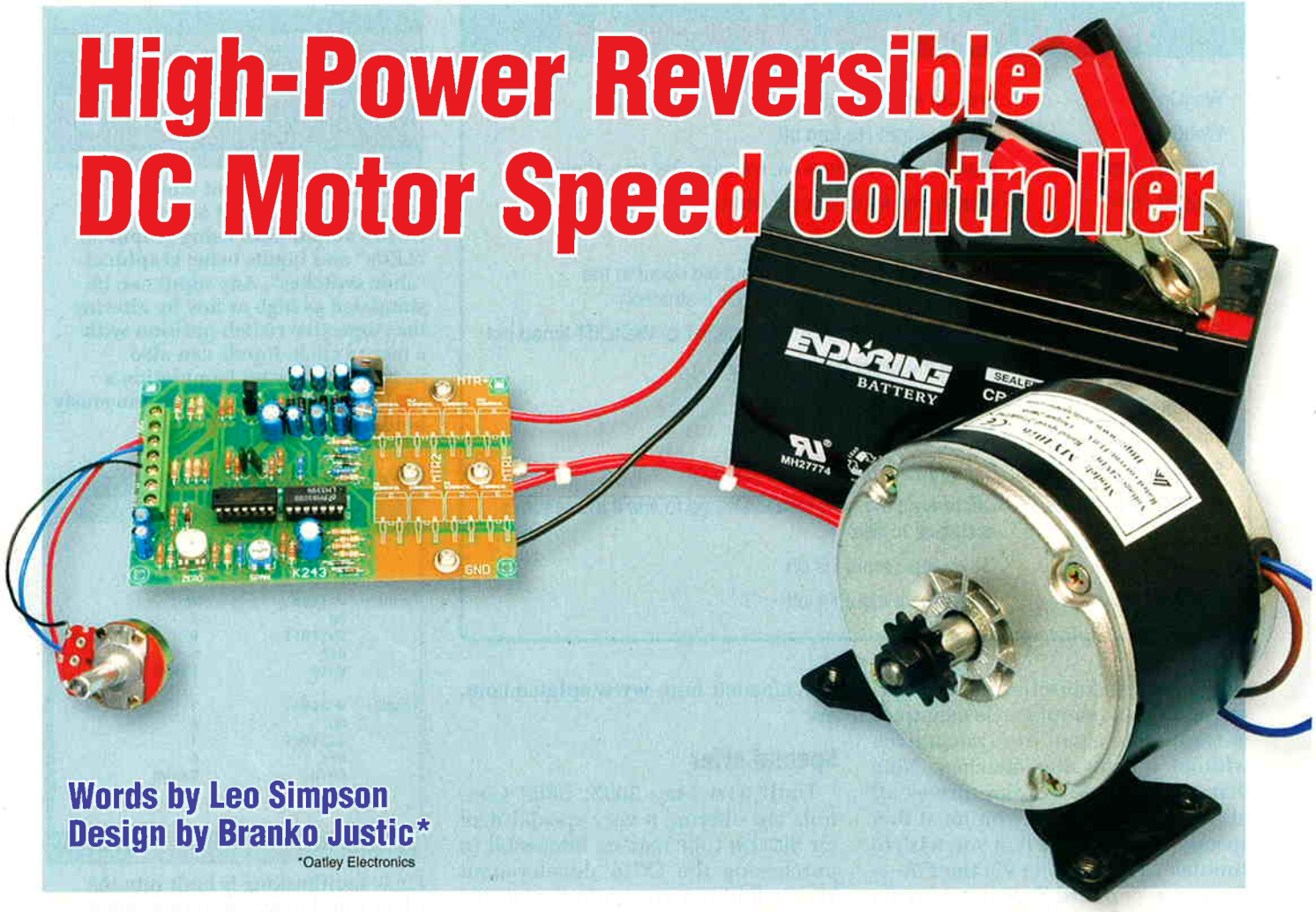


Fig.6: multitasking is built into the CC16 and it allows separate "slices" of a program (in this case TaskA and TaskB) to run simultaneously and independently of one another. Essentially, SPLat's simple multitasking instructions allow less experienced users to write more sophisticated programs.



The CC16BB Breakout Board is a useful add-on device to have during development, as it provides convenient screw terminal connections for power and all I/O connections, plus indicator LEDs on all I/O lines and DIP switches for activating inputs. It simply plugs into the four I/O connectors on the CC16 board.

High-Power Reversible DC Motor Speed Controller



Words by Leo Simpson
Design by Branko Justic*
*Oatley Electronics

This reversible DC motor speed controller uses a switchmode Mosfet bridge circuit that drives the motor. It can be controlled by a 1-2ms pulse train from a radio control system or by a single potentiometer to give forward/reverse throttle control. It can operate from 12V or 24V batteries at currents up to 20A with just four Mosfets in the bridge circuit.

OVER THE YEARS, motor speed controls have always been popular and this one is a beauty. Its Mosfet bridge circuit can be used for speed control in an R/C system using standard 1-2ms pulse control or you can simply connect a 10kΩ (linear) potentiometer or joystick to give single-handed forward/reverse control. As such, it would be suitable for a golf buggy, electric wheelchair, go-kart or whatever motor control application you have in mind.

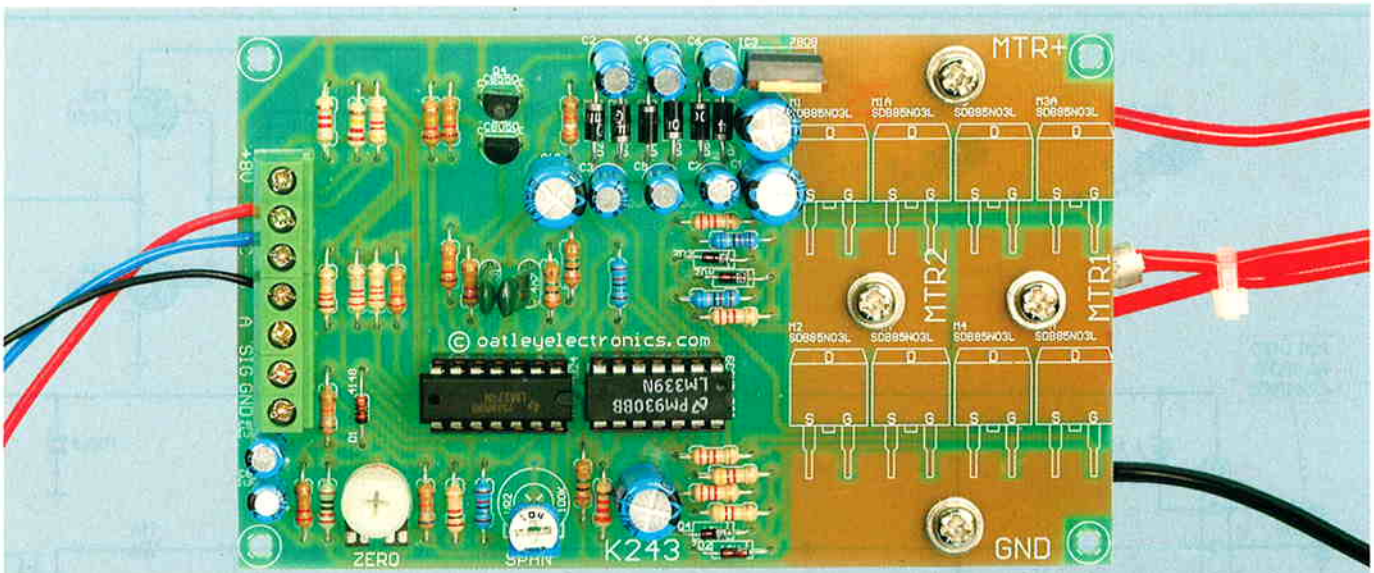
The bridge driver circuit employs 80A N-channel Mosfets that have an on-resistance of just five milliohms (5mΩ) and are suitable for 10-30V operation. In practice, that will mean operation from 12V or 24V batteries.

When tested with a loaded 24V motor at a continuous 10A the MOSFETs became just slightly warm. No additional heatsinking would be required for operation at 20A. **This test was conducted with four MOSFETs in the output bridge but there is provision for another four MOSFETs to be paralleled with the existing ones in the output bridge driver.** This would result in each of the paralleled MOSFETs having one quarter of the power dissipation when compared to the original single devices! In a 24V system, there would be no problem powering motors with a power rating of up to 1kW.

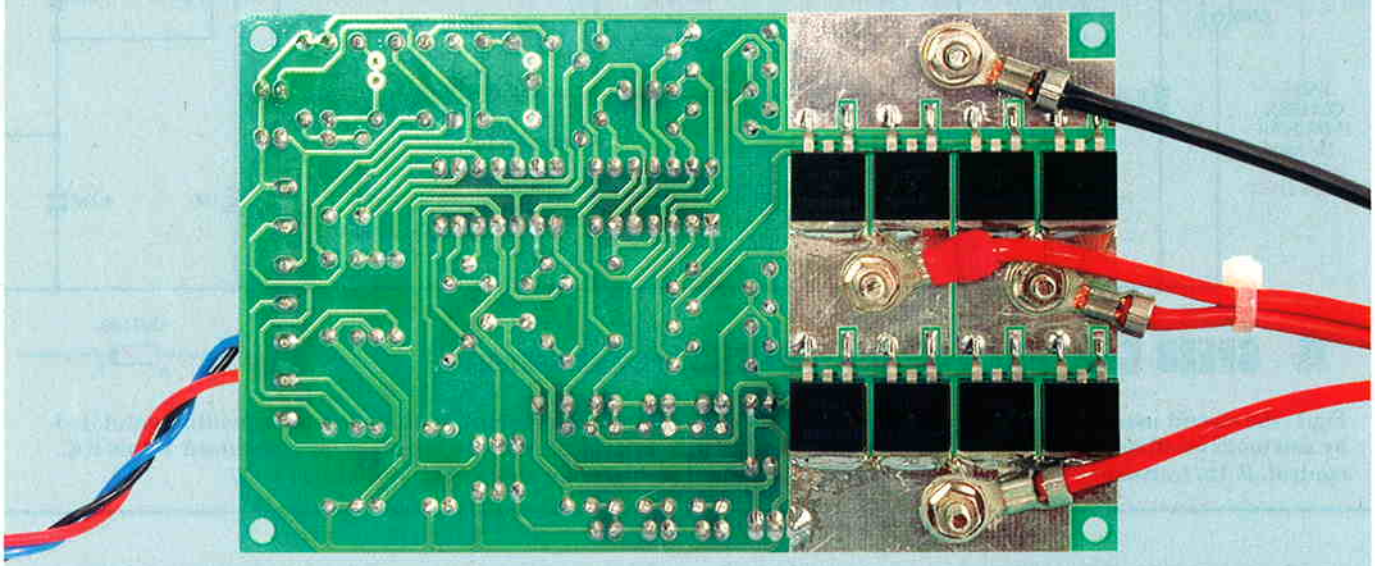
The complete circuit of the Speed Control For DC Motors is shown in Fig.1. With a total of four op amps, four comparators and four Mosfets, it may look fairly complicated but we can break it down into two sections in order to understand how it works.

Bridge circuit operation

First, let's have a look at the bridge output circuit which drives the motor. You first need to understand how a



This view shows the top side of the assembled PC board. Be careful not to get the two ICs mixed up and take care to ensure that all polarised parts (ICs, diodes, zener diodes & electrolytic capacitors) go in the right way around. The power Mosfets are mounted on the underside of the board (see below).



The surface-mount Mosfets are soldered to the underside of the PC board while the external connections are run via crimped eyelet assemblies which are fastened in place using M3 machine screws and nuts.

Mosfet bridge circuit drives the motor. Only two Mosfets turn on to drive the motor at any one time. The motor is connected to the terminals marked "Motor 1" and "Motor 2". For example, to drive the motor in the forward direction, Q7 and Q6 would be "on" while Q5 & Q8 would be "off". This would mean that current would flow from the positive rail V_{POS} (10-30V), through Q7, through the motor and then Q6 to the 0V (GND) rail.

To drive the motor in the reverse direction, Q5 & Q8 would be "on" while Q7 and Q6 would be "off".

Both the above forward and reverse conditions imply full speed operation with the respective Mosfets being turned on all the time. But this speed control is fully variable and the voltage to the motor is switched on and off rapidly at about 300Hz. For low speed, the turn-on pulses to the gates of the relevant Mosfets are quite short and for the high speeds they become progressively longer until at full speed the relevant gates are pulled high continuously.

OK. So we know that only two Mosfets in the bridge circuit are turned on at any one time to drive the motor in forward or reverse but an extra wrinkle in this circuit is that all four Mosfet are N-channel devices. In order to switch on the top Mosfet (Q5 or Q7), we need a gate voltage which is about 8V higher than the main (motor) supply voltage (V_{POS}). How do we manage that?

What we need first is a higher voltage supply to provide those high voltage gate signals Q5 & Q7. This is provided by op amp IC1b, complementary transistors Q3 & Q4 and the capacitors associated with D2-D7.

Op amp IC1b is connected to operate as a square wave oscillator at a frequency of 4kHz. Its output is about 6V peak-peak. This is coupled to the

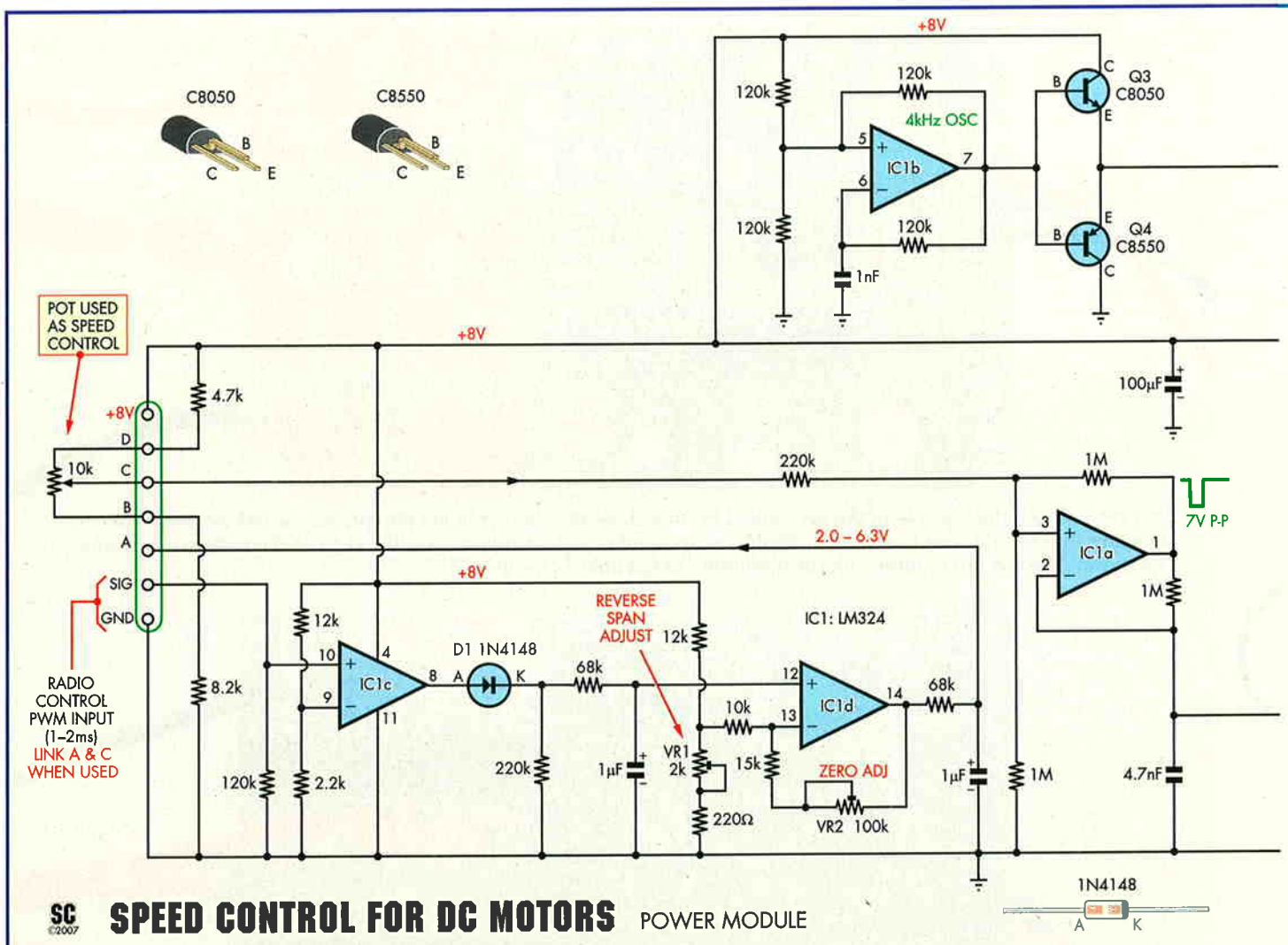


Fig.1: the circuit uses four Mosfets in a bridge configuration to drive the motor and these are pulse width modulated by sawtooth oscillator IC1a and comparators IC2a-IC2d. IC1c & IC1d provide an interface for a standard 1-2ms R/C control. IC1b, transistors Q3 & Q4 and diodes D2-D7 provide a high gate voltage for Mosfets Q5 & Q7.

bases of transistors Q3 & Q4 which are connected as complementary emitter followers to provide a buffered output from the op amp.

This combination produces an AC output voltage of 4.8V peak-peak. This AC output voltage is used to drive a Cockroft-Walton voltage multiplier made up of diodes D2-D7 and their associated 10µF capacitors. The DC output voltage from this multiplier is about 7-8V higher than the main supply voltage V_{POS}.

The V_{POS} + 8V supply is coupled to the gates of Q5 & Q7 via 6.8kΩ resistors and these connect, in turn, to the outputs of comparators IC2a & IC2b.

Note that this high voltage does not harm IC2 because it is an LM339 quad comparator with open-collector outputs. This means that its outputs are essentially the collectors of NPN transistors which can withstand any voltage up to +36V. In our circuit, the collector outputs of the four comparators are tied to V_{POS} + 8V via 6.8kΩ resistors for IC2a & IC2b and to V_{POS} via 4.7kΩ resistors for IC2c & IC2d.

Switchmode operation

For the following explanation, let's assume that the 10kΩ potentiometer connected to terminals B, C, & D has its wiper initially centred.

Op amp IC1a and its associated parts form an oscillator which produces a 300Hz sawtooth waveform of about 1.2V peak-peak. This sawtooth voltage is applied to the non-inverting input (pin 11) of IC2d and to the inverting input (pin 8) of IC2c.

The 39kΩ, 15kΩ and 33kΩ resistors form a voltage divider from the regulated +8V supply in order to bias pin 10 of IC2d at +4.4V and pin 9 of IC2c at +3V. Since the swing of the sawtooth waveform is actually sitting between the upper and lower threshold voltages, both comparators (ie, IC2c & IC2d) have an output of 0V – ie, there is no pulse output from the comparators and the motor is stationary.

Rotating the 10kΩ potentiometer so the voltage at its wiper is higher effectively raises the level of the sawtooth so that part of it intersects the 4.4V threshold for IC2d. This causes the output of IC2d to go high whenever the peaks of the sawtooth are above the +4.4V threshold.

The output pulses from IC2d are buffered by IC2a. This means that gate pulses are delivered to Q6 & Q7 which

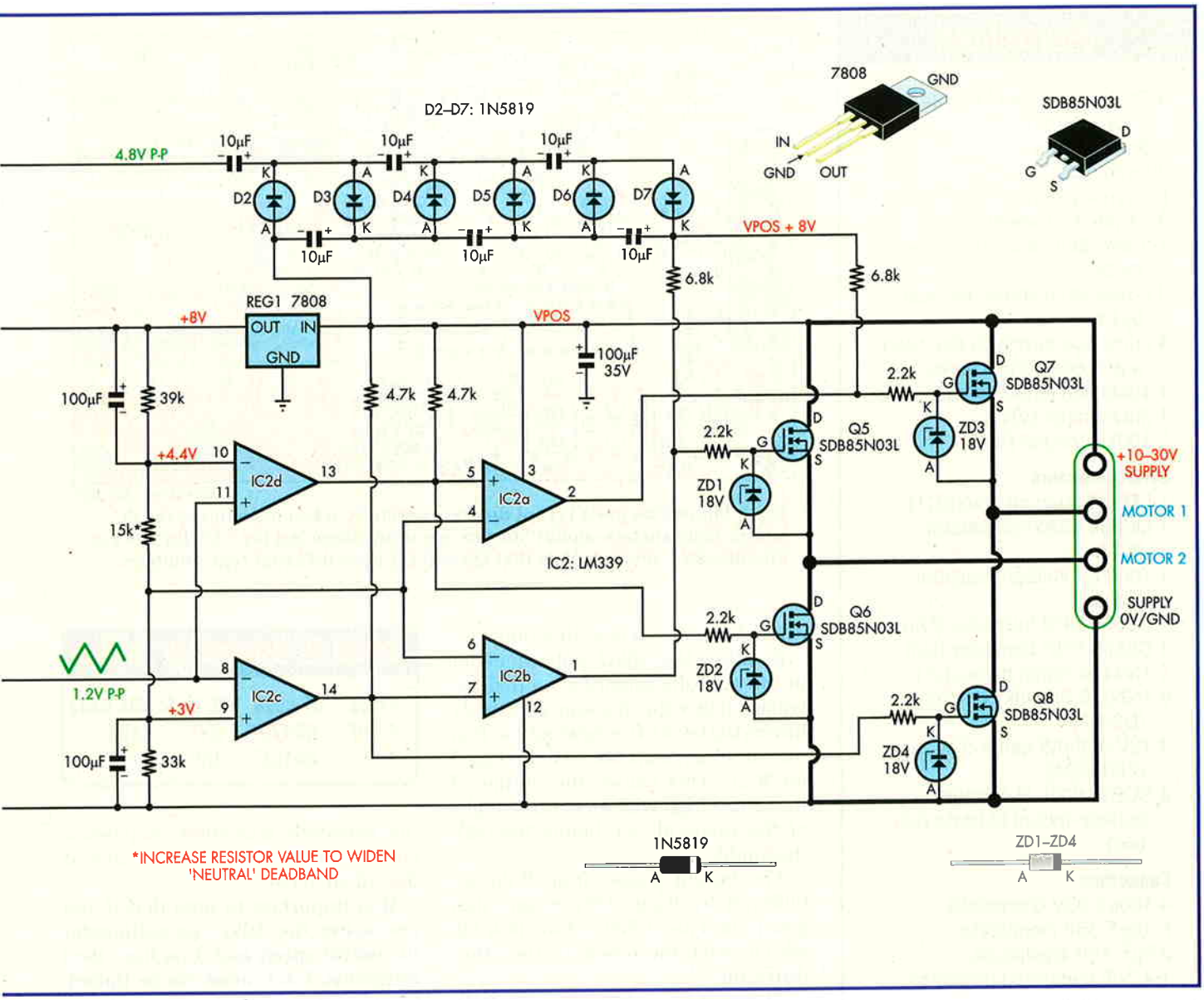


Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
3	1MΩ	brown black green brown	brown black black yellow brown
2	220kΩ	red red yellow brown	red red black orange brown
5	120kΩ	brown red yellow brown	brown red black orange brown
2	68kΩ	blue grey orange brown	blue grey black red brown
1	39kΩ	orange white orange brown	orange white black red brown
1	33kΩ	orange orange orange brown	orange orange black red brown
2	15kΩ	brown green orange brown	brown green black red brown
2	12kΩ	brown red orange brown	brown red black red brown
1	10kΩ	brown black orange brown	brown black black red brown
1	8.2kΩ	grey red red brown	grey red black brown brown
2	6.8kΩ	blue grey red brown	blue grey black brown brown
3	4.7kΩ	yellow violet red brown	yellow violet black brown brown
5	2.2kΩ	red red red brown	red red black brown brown
1	220Ω	red red brown brown	red red black black brown

Parts List

1 PC board coded OE-K243, 115 x 71mm
4 3mm screws
4 3mm nuts
8 3mm washers
2 14-pin IC Sockets
1 3-way 5mm screw terminal block
2 2-way 5mm screw terminal blocks
4 crimp eye terminals (for supply and motor connections)
1 10kΩ (lin) potentiometer
1 2kΩ trimpot (VR1)
1 100kΩ trimpot (VR2)

Semiconductors

1 LM324 quad op amp (IC1)
1 LM339 quad comparator (IC2)
1 7808 8V voltage regulator (REG1)
1 C8050 NPN transistor (Q3)
1 C8550 PNP transistor (Q4)
1 1N4148 signal diode (D1)
6 1N5819 Schottky diodes (D2-D7)
4 18V 400mW zener diodes (ZD1-ZD4)
4 SDB85N03L N-channel surface-mount Mosfets (see text)

Capacitors

4 100µF 35V electrolytic
6 10µF 35V electrolytic
2 1µF 16V electrolytic
1 4.7nF metallised polyester (greencap)
1 1nF metallised polyester (greencap)

Resistors (0.25W, 1% or 5%)

3 1MΩ	2 12kΩ
2 220kΩ	1 10kΩ
5 120kΩ	1 8.2kΩ
2 68kΩ	2 6.8kΩ
1 39kΩ	3 4.7kΩ
1 33kΩ	5 2.2kΩ
2 15kΩ	1 220Ω

Kit availability

This project was produced by Oatley Electronics who own the design copyright. Kits (Cat. K243) can be purchased from Oatley Electronics Pty Ltd, PO Box 89, Oatley, NSW 2223. Phone: (02) 9584 3563 Fax: (02) 9584 3561 http://www.oatleyelectronics.com

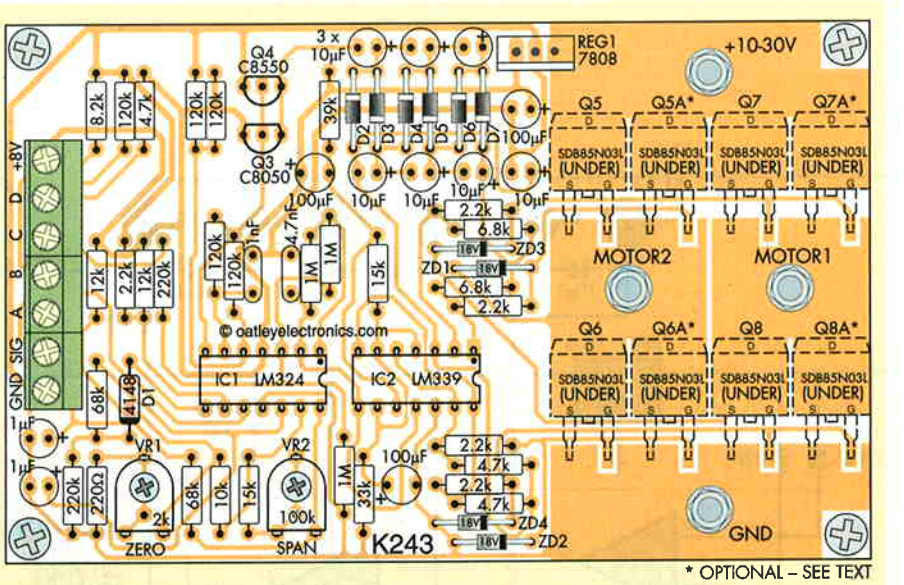


Fig.2: follow this parts layout diagram carefully when assembling the PC board. Eight surface-mount Mosfets are shown here but the "A" devices are all optional – see text. Note that Q3 and Q4 have different type numbers.

drive the motor in one direction.

Rotating the 10kΩ potentiometer in the opposite direction, so that the voltage at its wiper is lower, effectively lowers the level of the sawtooth so that part of it intersects the +3V threshold for IC2c. This causes the output of IC2c to go high whenever the troughs of the sawtooth are below the +3V threshold.

The output pulses from IC2c are buffered by IC2b. This means that gate pulses are delivered to Q5 & Q8 which drive the motor in the other direction.

The only part of the circuit which remains to be explained is that comprising op amps IC1c & IC1d and associated components. This takes the standard 1-2ms pulse from a radio control decoder and converts it to a varying DC level to control the sawtooth oscillator of IC1a.

It does this in the following way. The pulse signal is first fed to IC1c which is connected as a comparator to buffer and "limit" the signal before it is fed to diode D1 and filtered by the 1µF capacitor. The resulting DC level represents the width of the input pulses. Short pulses give a low level while long pulses give a higher level. This is amplified and level-shifted by op amp IC1d and then fed to terminal A on the connector strip.

This is linked to terminal C on the connector strip and fed via the 220kΩ resistor to IC1a to level-shift the sawtooth waveform and hence control motor speed and direction as described above.

Table 2: Capacitor Codes

Value	µF code	IEC Code	EIA Code
4.7nF	.0047µF	4n7	472
1nF	.001µF	1n0	102

It is important to note that if you are using the 10kΩ potentiometer to control speed and direction, then terminals A & C must not be linked. Conversely, if you are using 1-2ms pulse control, then terminals A & C must be linked and the 10kΩ potentiometer must be omitted.

Note that transistors Q1 & Q2 are missing from the circuit and PC board. These were present in an earlier prototype but have been designed out the circuit.

Construction

All the components of the Speed Control, with the exception of the 10kΩ potentiometer, are mounted on a PC board measuring 115 x 71mm. Assembly is best started with the SDB85N03L surface-mount Mosfets. Solder the legs of the Mosfets first and then solder the metal tag of each Mosfet to the PC board. A wooden clothes peg can be used to hold each Mosfet in place while it is soldered. Note that you will need a larger than normal

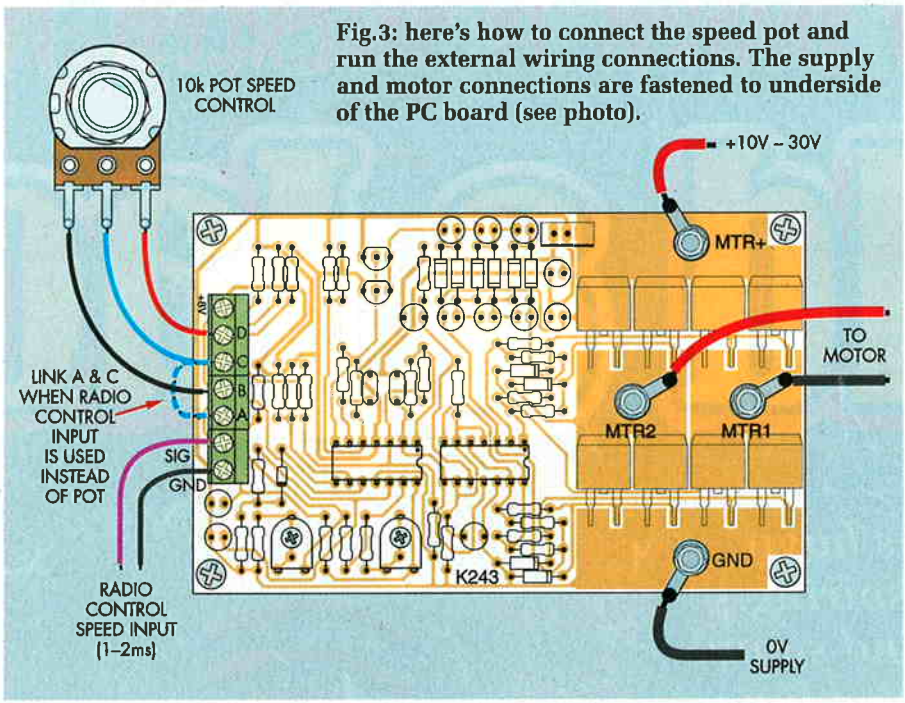


Fig.3: here's how to connect the speed pot and run the external wiring connections. The supply and motor connections are fastened to underside of the PC board (see photo).

soldering iron to do this because most temperature-controlled irons will not have enough power to do the job.

Make sure you place and solder each Mosfet in the correct location, so as to leave room for the additional Mosfets if they need to be fitted as well.

With the Mosfets installed, you can then solder in all the smaller components. Make sure that the diodes, transistors, ICs and voltage regulator (REG1) are correctly located and oriented. Mistakes here can cause major damage if not discovered before power is applied.

In particular, note that Q3 and Q4 are different. Q3 is a C8050, while Q4 is a C8550. Don't mix them up.

Check each resistor's value with your digital multimeter, before it is installed. Finally, make sure that you install each electrolytic capacitor with the correct polarity.

Testing

When assembly is complete, check all your work very carefully. As noted above, any mistake in component placement or polarity may cause damage when the supply is connected.

When everything checks OK, connect a 12V battery or DC power supply. Do not connect the motor yet. Now check that +8V is present at the output of voltage regulator REG1 and on pin 4 of IC1. +12V should be present at pin 3 of IC2. That done, check that the voltage multiplier is working by measuring the voltage at the cathode end (white band) of diode D7. It should be about +20V or thereabouts.

With the 10kΩ potentiometer centred (ie, for zero motor speed in either direction), the voltages at pins 1, 2, 13 & 14 of IC2 should all be low (ie, less than about 100mV) and similarly, the voltages at the Motor1 and Motor2 outputs should also be close to 0V.

Now try rotating the 10kΩ pot in one direction and then other. You should find a proportional increase in the voltage at the Motor1 or Motor2 terminals.

If all these checks are OK, you should be able to then connect the motor and control its speed. Note that as its speed is increased, the motor will produce a more or less musical tone. That is due to the 300Hz switching frequency.

Next month, we will describe a companion interface board which provides a hand throttle control and has a toggle switch for motor direction. SC

WARNING!

The supply polarity is crucial. Reversed polarity may destroy the unit.

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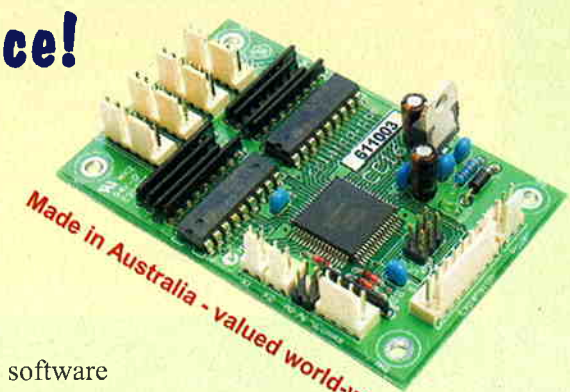

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IT SIZZLES! IT SPARKS! IT CRACKLES! IT'S

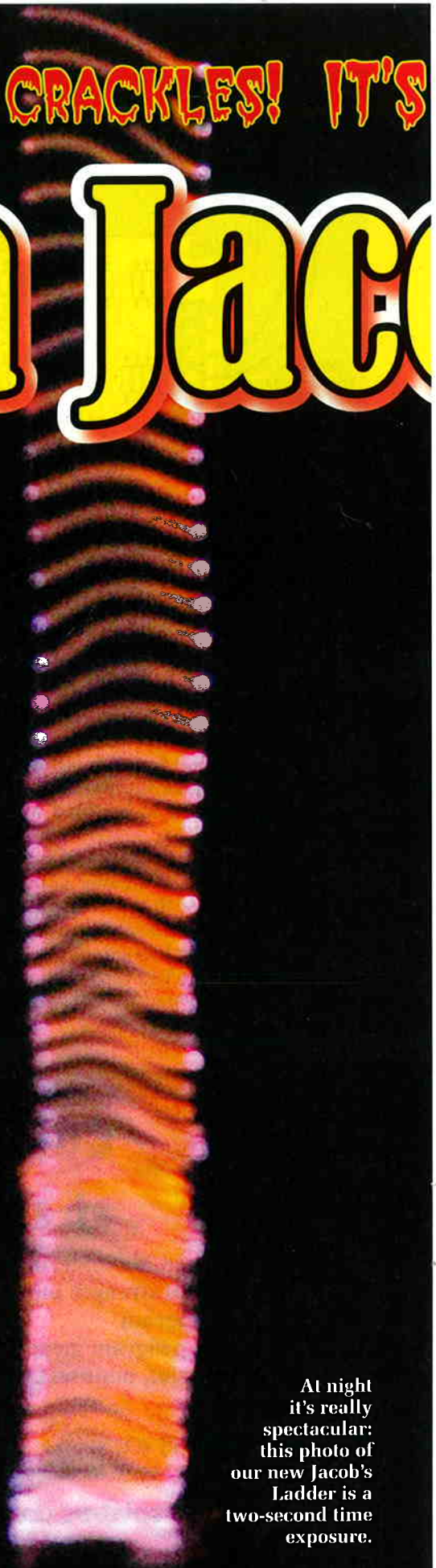
Build a Jac

High voltage displays have always been awe-inspiring. They not only look and sound spectacular – they even have a pungent smell, caused by the ozone which is generated by any high voltage discharge. One of the most fascinating high voltage displays is the Jacob's Ladder, in which a series of sparks continually climb between two vertical wires.

Warning!

This Jacob's Ladder display uses very high voltage which can give a nasty shock. Do not put your fingers *anywhere near* the display, the coil, nor any part of the circuit while ever power is applied.

By Leo Simpson



At night it's really spectacular: this photo of our new Jacob's Ladder is a two-second time exposure.

FASCINATING! IT'S ELECTRIFYING!

ob's Ladder

SO HOW *DO* YOU make an electric discharge climb a pair of wires? In practice, it is quite easy. The two vertical wires are spaced close together at the bottom and slightly splayed apart to increase the gap as the sparks rise.

So why do they rise at all? Surely the spark would always take the shortest route rather then extend itself as it travels upwards?

But the spark discharge is actually taking the shortest path, or rather, the *easiest* path from one electrode to the other. Initially, the discharge does take the shortest path which is at the bottom of the wires. But the continuous spark discharge is hot and heats up the air around it. This heated ionised air rises, carrying the discharge up with it until the gap between the two electrode wires is too large to maintain the spark. The discharge then starts at the bottom again and the cycle continues.

Back in September 1995 we produced a Jacob's Ladder circuit which has been popular ever since. But just recently our attention was drawn to a number of mains-powered discharge circuits on the internet. While quite spectacular they are also quite dangerous.

We got to thinking: how can we produce something just as spectacular but not mains-powered? Our original Jacob's Ladder circuit was based on a conventional 12V ignition coil and we realised that today's cars have very powerful ignition systems.

So why not revise the circuit with a higher-powered coil out of a late model car?

In practice, it turned out to be not quite so simple. While all current model cars use engine management and high-energy ignition systems, they use a wide variety of ignition coil arrangements.

Some use direct fire ignition systems, with a coil right on top of each spark plug. Others use a conventional coil and distributor while some others such as the Holden Commodore use three double-ended coils to run a V6 motor.

We decided that the double-ended coil arrangement was probably the best for our purpose since it should have much higher voltage than a coil which only has to fire one spark plug at a time.

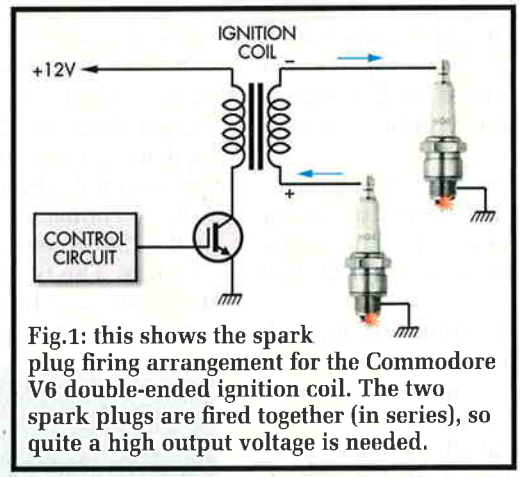
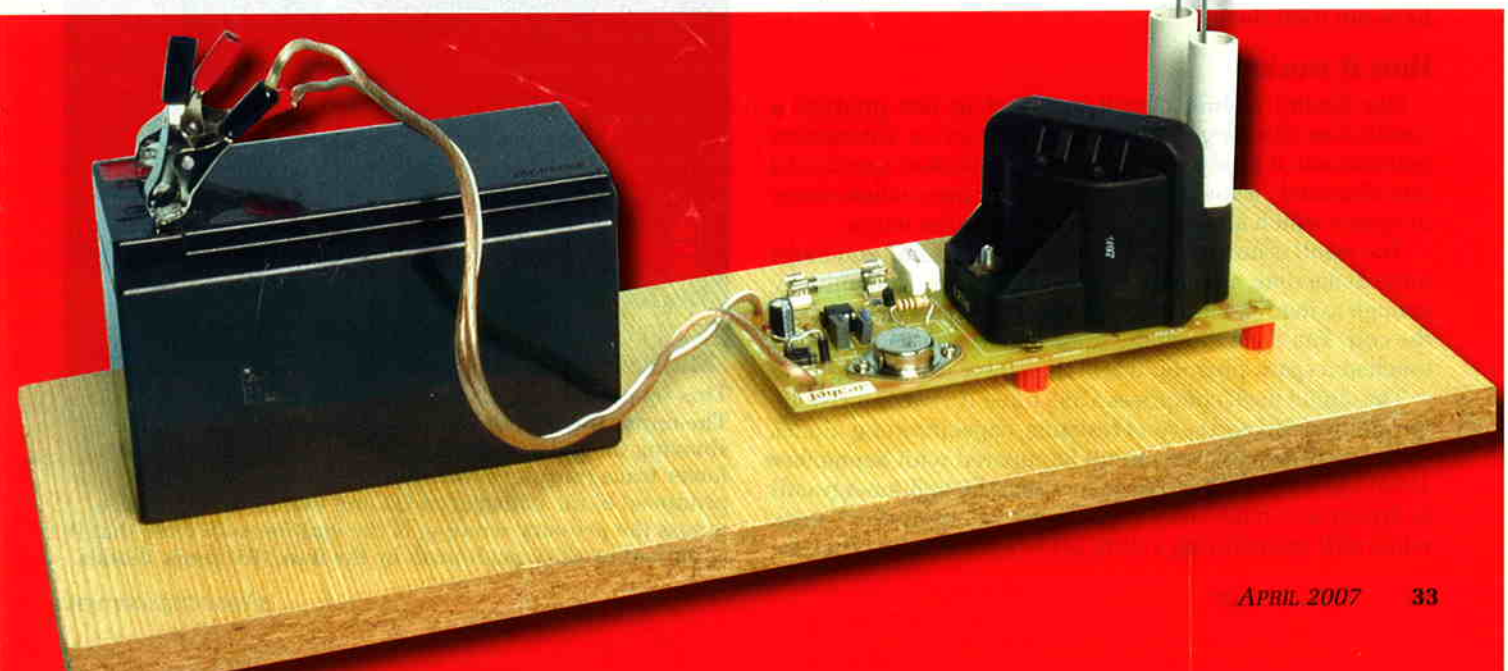


Fig.1: this shows the spark plug firing arrangement for the Commodore V6 double-ended ignition coil. The two spark plugs are fired together (in series), so quite a high output voltage is needed.



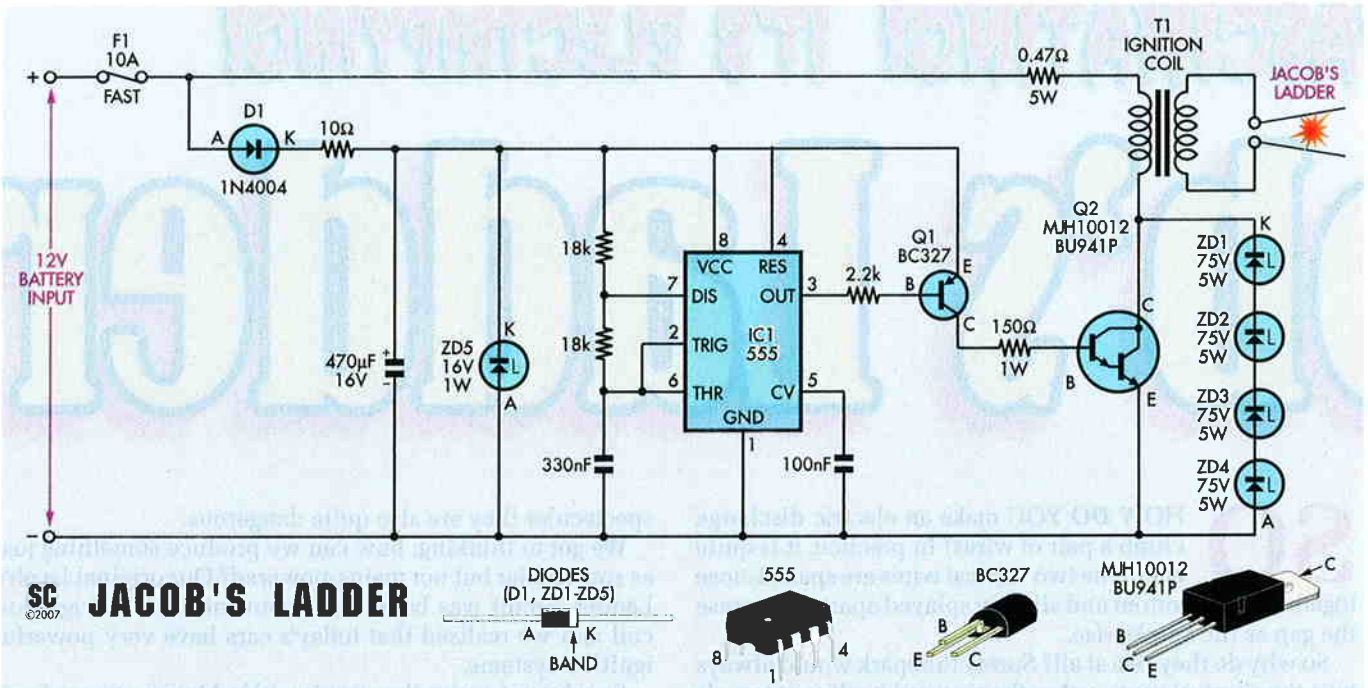


Fig.2: the circuit uses a 555 timer (IC1) to pulse transistors Q1 & Q2 on and off at 75Hz. Q2 drives a Commodore V6 ignition coil and this delivers high voltage pulses to the Jacob's Ladder wires.

By way of explanation, the Commodore ignition coil has two high voltage terminals, each of which is connected to a spark plug. So when the coil fires, it drives two spark plugs in series; one will be on the power stroke while the other will be on the exhaust stroke and thus will be "wasted". The arrangement is shown in Fig.1.

The only drawback is that Commodore ignition coils come in an assembly of three, all attached to a common mounting plate. This assembly is quite expensive to buy, whether new or from a wrecker – you can expect to pay around $150 or more. Too much!

However, you can purchase single ignition coils for a VN Commodore (the first with the 3.8-litre V6) and that is what we did. Even so, they typically cost around $50 although you might get one at lower cost from a wrecker.

By the way, it may be possible to adapt other double-ended coils, such as from a Toyota V6 Camry or Avalon, but we have not tried them.

How it works

Our Jacob's Ladder circuit does not in fact produce a continuous discharge. Since it is based on an automotive ignition coil, it produces continuous individual sparks, at a rate of around 75 sparks/second. So you have a whole series of sparks which appear to be climbing up the wires.

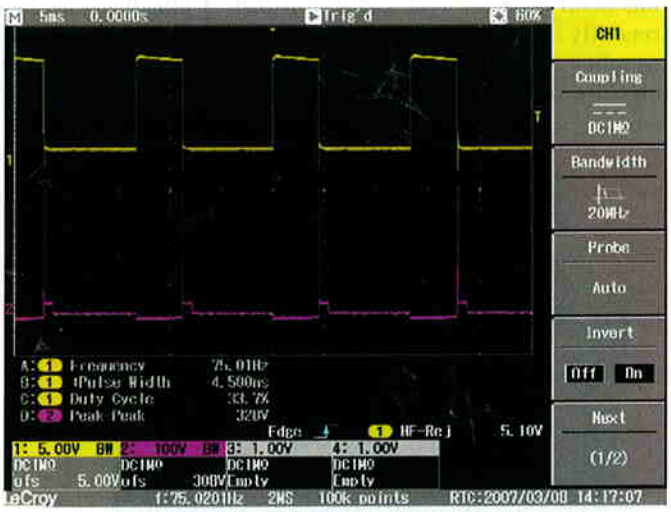
The result is noisy and smelly (from the ozone) and looks quite dangerous, as it indeed it could be, if you are unlucky enough to inadvertently touch the high voltage terminals of the coil. You'd get much the same belt as you would if you touched a spark plug top while the motor is running.

The circuit itself comprises a 555 timer IC, two transistors, the ignition coil and several resistors, capacitors and diodes – see Fig.2. This revised circuit (compared with September 1995) has been modified to ensure that the high-energy coil is driven to a reasonably high current of around 5A peak while still maintaining a duty cycle which means that the main power transistor does not get too hot – it operates without a heatsink.

IC1 is a 555 timer used to produce the short pulses. Note that we used a standard 555 timer here since it is more rugged than the CMOS (7555) version and less likely to be damaged by any high voltage transients which may be present on the PC board.

IC1 is connected to oscillate at about 75Hz, as determined by the 330nF capacitor at pin 6 and the two associated 18kΩ resistors. The two resistors set the duty cycle of the pulse train delivered by pin 3 at about 66%.

When pin 3 is high, transistor Q1 is held off and no base



This scope screen grab shows the circuit operation. The upper trace (yellow) is taken at the collector of Q1, showing the pulse waveform fed to the base of Q2. The lower trace (purple) shows the high voltage waveform produced at the collector of Q2 and therefore the voltage across the primary winding of the ignition coil. Note that it is limited to 328V peak-peak by the four 75V zener diodes.

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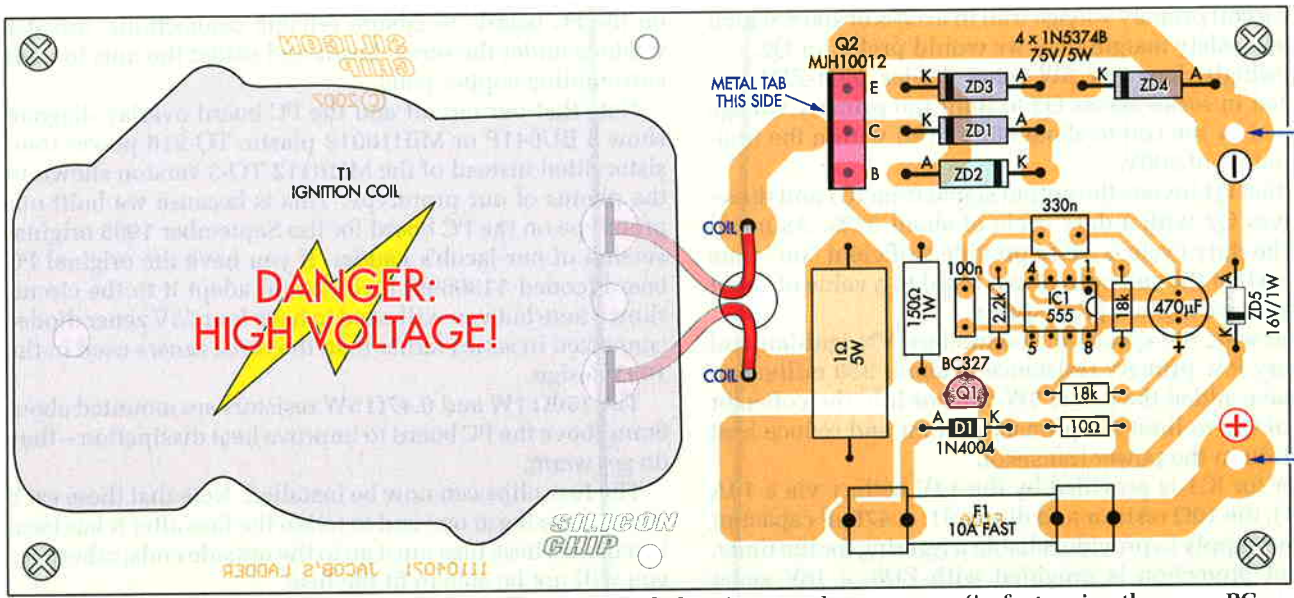
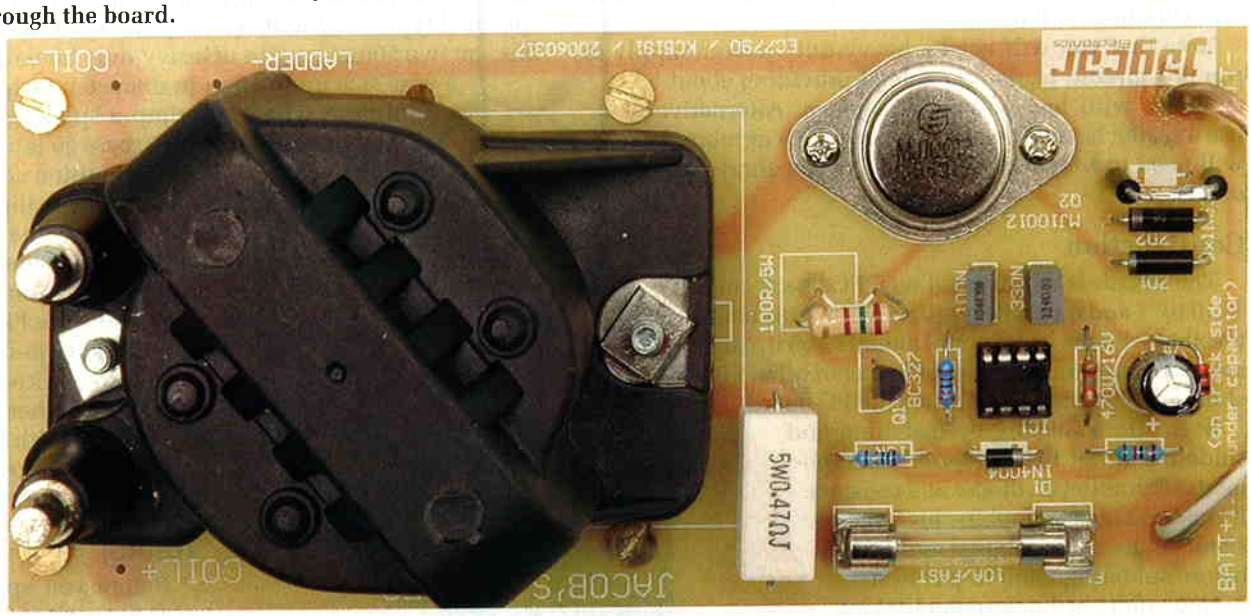


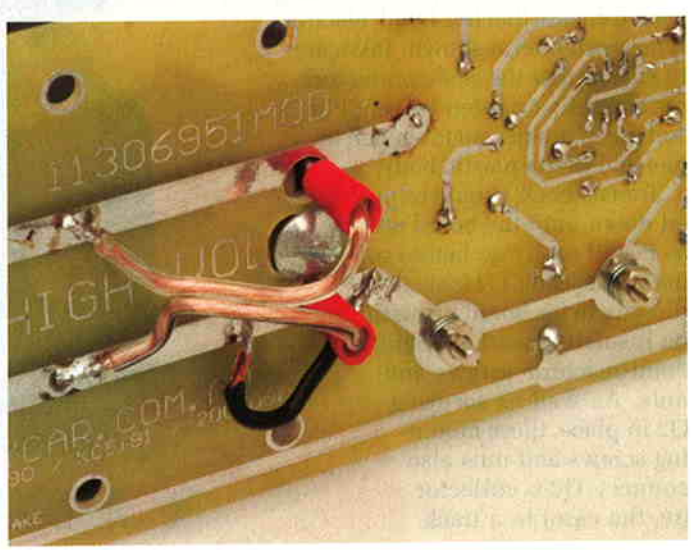
Fig.3: the component overlay for the PC board. The photo below is an early prototype (in fact, using the same PC board as our original Jacob's Ladder) – hence the TO3 transistor and some other circuit changes. However, it does give a good idea of how the Commodore coil is mounted in the new version. At the bottom of the page is a section of the reverse side of the board showing how connection is made to the primary of the ignition coil via spade lugs passing through the board.



current flows in Q2. When pin 3 goes low, Q1 is switched on due to the base current flow through the 2.2kΩ resistor and Q1 switches on Q2 via its 150Ω base resistor. The coil now begins to charge via fuse F1 and the 0.47Ω 5W resistor. The instant pin 3 goes high again, Q2 switches off and the coil develops a high voltage and generates a spark across the gap.

Q2 is an MJH10012 Darlington power transistor, specifically designed as a coil driver in automotive ignition systems. It has a 500V collector-emitter rating so it can withstand the high voltages developed across the coil's primary winding.

Depending on the spark gap, the coil's peak primary voltage may only be about 300V or so, but if the gap is very large or the coil is operated without any EHT output lead, the secondary voltage can be excessive and there can be a flashover across the coil's high voltage terminals. In practice, our scope measurements showed that this could



produce a coil primary voltage well in excess of 400V, which leaves less safety margin than we would prefer for Q2.

Accordingly, four 75V 5W zener diodes, ZD1-ZD4, are connected in series across Q2 to limit the primary voltage developed by the coil to about 300V, well within the transistor's rating of 500V.

Note that Q1 inverts the output signal from IC1 and therefore drives Q2 with a duty cycle of about 34%. As noted above, the duty cycle is set to provide sufficient "on" time for Q2, so that the coil current can build to a value of about 5A peak, ensuring hot, juicy sparks.

By the way, the specified Commodore VN ignition coil has a very low primary resistance of about 350 milliohms so we have added the 0.47Ω 5W resistor into the collector circuit of Q2, to limit the primary current and reduce heat dissipation in the power transistor.

Power for IC1 is provided by the 12V battery via a 10A fuse (F1), the 10Ω resistor and diode D1. A 470µF capacitor filters the supply to provide reliable triggering for the timer. Transient protection is provided with ZD5, a 16V zener diode. A 100nF capacitor at pin 5 filters the trigger point voltage to ensure that the timer does not false trigger.

Diode D1 offers reverse polarity protection for IC1, while the fuse protects the battery from supplying excessive current should a fault occur.

Note that you will need a heavy-duty power supply to run this circuit; ie, one capable of providing about 5A or more, with low output impedance. Alternatively, use a sealed lead acid battery rated at 7Ah or more. You will need to keep it charged up between short periods of use.

Construction

The circuit is constructed on a PC board coded 11104071 and measuring 170 x 76mm. This board, together with the ignition coil mounted on it, can be mounted on a suitable piece of timber or MDF. Fig.3 shows the assembly details for the PC board.

Begin the assembly by installing and soldering in all the low profile components such as the IC, diodes and resistors. It is a good idea to double-check the resistor values using a digital multimeter before soldering them in position.

Now solder in the capacitors, taking care to ensure that the 470µF electrolytic is oriented as shown. Take care to ensure that the semiconductors are correctly oriented as well. Pin 1 of the IC is adjacent to a notch in one end of the plastic body.

Transistor Q2 should be pushed down onto the board as far as it will easily go before soldering its leads. Q2 is secured directly to the board (ie, with no insulating washer) using 3mm machine screws and nuts. As well as securing Q2 in place, these mounting screws and nuts also connect Q2's collector (ie, the case) to a track on the PC board. To ensure reliable connections, use star washers under the screw heads and solder the nuts to their surrounding copper pads.

Note that our circuit and the PC board overlay diagram show a BU941P or MJH10012 plastic TO-218 power transistor fitted instead of the MJ10112 TO-3 version shown in the photos of our prototype. This is because we built our prototype on the PC board for the September 1995 original version of our Jacob's Ladder. If you have the original PC board (coded 11306951), you could adapt it to the circuit shown here but you will need to have four 75V zener diodes connected in series rather than the three zeners used in the 1995 design.

The 150Ω 1W and 0.47Ω 5W resistors are mounted about 6mm above the PC board to improve heat dissipation – they do get warm.

The fuse clips can now be installed. Note that these each have a little lug at one end to retain the fuse after it has been installed. These lugs must go to the outside ends; otherwise you will not be able to fit the fuse.

The ignition coil is secured to the PC board using two 25mm long M4 screws, with nuts and lockwashers. The connections to its primary winding are made underneath the PC board, through holes, using crimped spade connectors. The specified type is red with a 5mm wide spade section. To do this, cut two 50mm lengths of heavy-duty hookup wire with a wire size up to 1mm in diameter. Strip both ends of each wire and crimp a spade connector to one end of each – these go into the underside of the ignition coil via 8mm clearance holes on the underside of the PC board. The other ends of the wires are soldered to their respective points on the top of the PC board – see Fig.3.

Then fit the twin-lead battery cable (red to positive, black to negative). The other end of this cable is fitted with large (30A) battery clips. Now you are ready to test the circuit.

The two lengths of PVC tube shown here do a great job of moving the spark up the wires, away from the soldered terminals. There was just one tiny problem: after prolonged use they started to catch on fire . . . so we are not recommending they be used!

Testing

Before you apply power, you must provide a temporary spark gap for the ignition coil, otherwise it may be damaged by an internal discharge. The gap can be made quite simply with a paper clip. Push it over one of the high voltage terminals and then position it so that any spark can jump about 20mm across to the other high voltage terminal.

Now for the smoke test. As soon as you connect the power, there should be a continuous stream of sparks across the

temporary spark gap. Do not attempt to touch the coil (nor anything else!) while power is applied because it can give you a nasty shock!

If everything works OK, disconnect the battery leads and mount the whole PC board assembly on a suitable piece of timber or MDF (medium density fibreboard). We mounted our prototype using four woodscrews and some plastic spacers.

We made our Jacob's Ladder spark gap with two 30cm lengths of springy steel wire. These were attached to the high voltage terminals of the ignition coil by soldering each to bare spark plug connectors.

These connectors are not particularly easy to find these days but we tracked them down at a specialist auto parts supplier. Your local auto electrician could be another possibility. If you cannot find any, perhaps you could "rat" some old spark plug leads and extract the connectors.

Being designed for crimping, they may also not be easy to solder to – we managed by filing the surface of the connectors to a bright surface and then immediately soldering the wires on with a large (100W) hot soldering iron (normal 30W-ish hobby electronics irons don't stand a chance!).

Note that the two wires should be as straight as possible without any kinks but are slightly splayed apart to make the spark discharge run smoothly up the wires. Any slight kinks will mean that the sparks will not progress smoothly up the ladder but will tend to "stick" at the kinks. So keep the wires as straight as possible and splay them apart very slightly so that the gap at the top is no more than about 20mm.

Coat-hanger wire would probably work just as well, bearing in mind that it can be difficult to get coat-hanger wire absolutely straight.

Don't use electrical conduit

We originally placed a 50mm length of 20mm electrical conduit over both high voltage terminals of the coil (as seen in the photographs). This stopped any tendency for the spark to jump between any slight bumps or protuberances on the spark plug connectors and made the sparks climb up the wires much more smoothly. Unfortunately, though, after a prolonged period of use, these got carbonised and started to catch fire. Well, it seemed like a good idea at the time. If you find the sparks jump between the terminals and do not rise up the wires, try using proper spark plug insulating boots. DO NOT use electrical conduit. SC

PARTS LIST – JACOB'S LADDER

1 PC board, code 11104071, 170 x 76mm
1 VN Commodore V6 12V ignition coil (see text)
2 3AG PC mount fuse clips
1 10A 3AG fuse
2 red 5mm crimp spade terminals
2 25mm M4 screws, nuts and star washers
1 red battery clip
1 black battery clip
2 bare spark plug connectors (see text)
2 spark plug insulating boots (if required – see text)
2m length of twin red/black automotive wire
2 300mm lengths of 1mm steel or copper wire
1 timber or MDF baseboard
1 12V DC 5A power supply or SLA battery (see text)

Semiconductors
1 555 timer (IC1)
1 BC327 PNP transistor (Q1)
1 MJH10012, BU941P 500V NPN TO-218 Darlington transistor (Q2)
1 1N4004 1A diode (D1)
4 75V 3W or 5W zener diodes (ZD1-ZD4)
1 16V 1W zener diode (ZD5)

Capacitors
1 470µF 16V PC electrolytic
1 330nF MKT polyester
1 100nF MKT polyester

Resistors (0.25W 1%)
2 18kΩ 1 2.2kΩ 1 150Ω 1W 1 10Ω
1 0.47Ω 5W wirewound

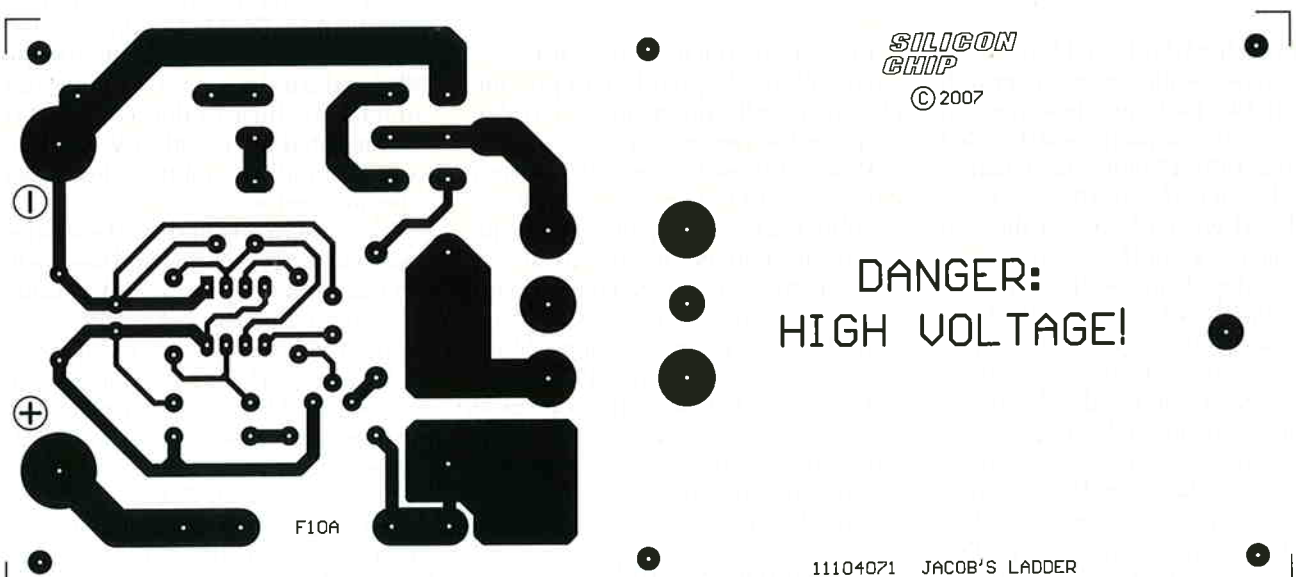
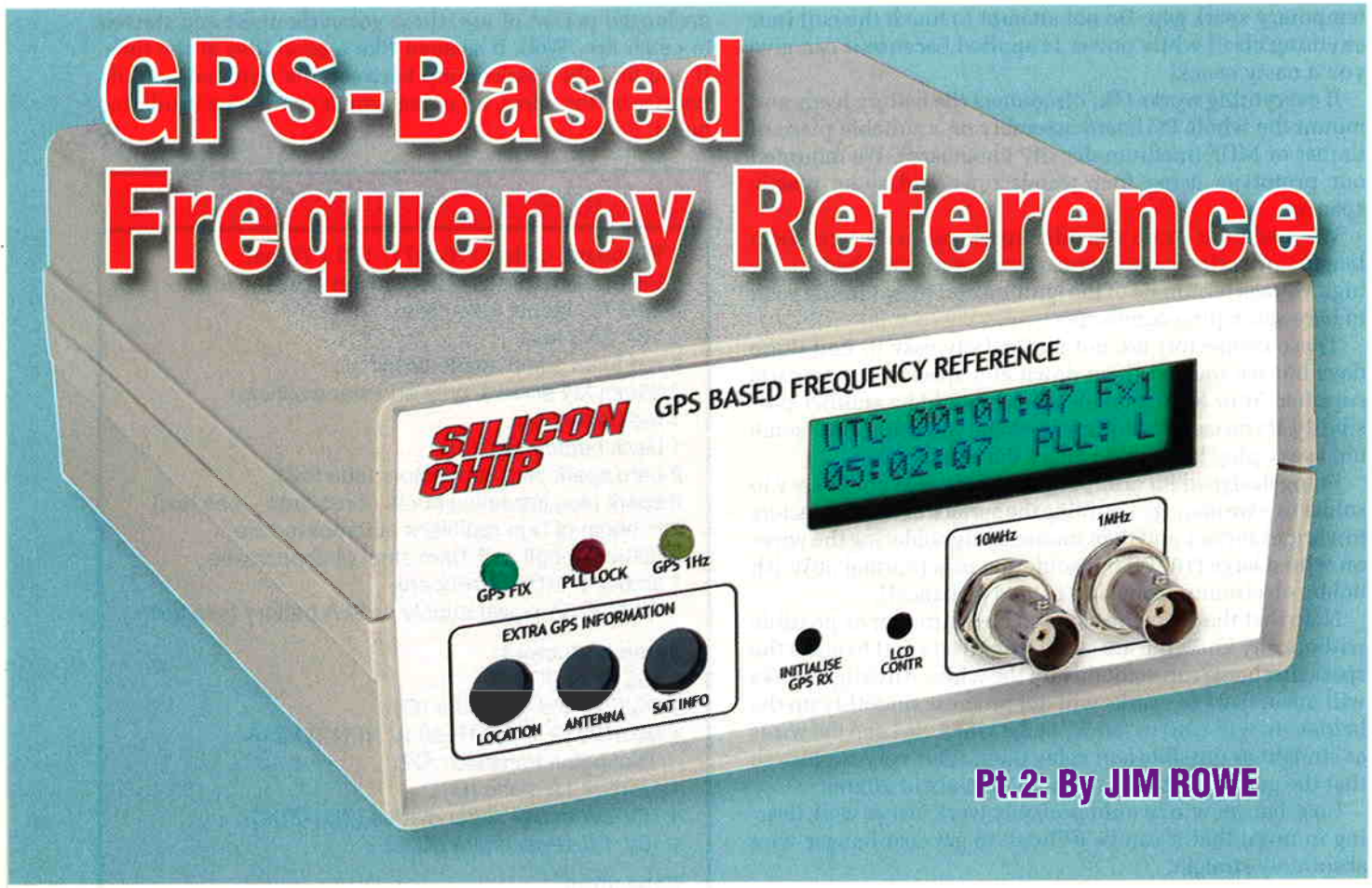


Fig.4: actual size artwork for the PC board. The corner mounting holes and the two ignition coil mounting holes should be drilled at 5mm while the three clearance holes for the coil primary wires should be drilled at 8mm.

GPS-Based Frequency Reference



Pt.2: By JIM ROWE

Last month, we published the circuit for our new GPS-Based Frequency Reference and described how it works. This month, we show you how to build and adjust it.

Building the GPS-Based Frequency Reference is quite straightforward, since all the parts are mounted on two PC boards: a main board coded 04103071 (143 x 123mm) and a smaller display board coded 04103072 (145 x 58mm). All wiring between the two boards is via a short 16-way ribbon cable, fitted with an IDC line socket at each end (to link CON6 & CON9).

Everything fits snugly inside an ABS plastic instrument case measuring 158 x 155 x 65mm, the display board mounting vertically at the front. As you can see from the diagrams and photos, the main board has a small rectangular extension at front right for the 10MHz and 1MHz output connectors (CON1 and CON2), while the display board has a matching rectangular cutout to fit around these connectors.

In addition, the display board has a small cutout at upper left, to provide clearance for the interconnecting cable between the two boards.

When the case is assembled, output connectors CON1 and CON2 are accessible via the front panel, while the remaining connectors are all accessible via the rear panel. The LCD and status LEDs are also at the front, along with the three main control pushbutton switches (S1-S3). The GPS receiver initialisation button (S4) is operated via a small access hole in the front panel, along with a similar access hole for adjusting the display contrast (via trimpot VR2).

Main board assembly

Fig.6 shows the parts layout on the main board. Begin by installing the wire links, then install PC stakes at test points TP1-TP4 and the adjacent TPG and GND terminals.

Follow these parts with the resistors, diodes and the MKT and ceramic capacitors. Table 1 shows the resistor colour codes but you should also check them using a DMM, as some colours can be difficult to read. Note that the 10kΩ and 20kΩ resistors in the resistor ladder DAC (just to the left of IC12) are mounted in inverted-V fashion, to fit them all in. Table 2 shows the capacitor codes.

Take care to ensure that the diodes are all correctly oriented and be sure to use the correct type at each location.

Next, fit the IC sockets if you're using them (they're recommended for this project). The IDC header pin connectors CON6 & CON7 can then go in, followed by BNC connectors CON1-CON4, power input connector CON5 and RCA connector CON8.

The finned heatsink for regulator REG1 is next on the list. Make sure it's seated all the way down on the PC board before soldering its mounting pins to the board pads.

Regulator REG1 is mounted vertically against the heatsink and is attached to it using an M3 x 6mm machine screw (this goes into a tapped hole in the heatsink). Apply a thin smear of heatsink compound to both the back of the regulator and the heatsink surface before screwing them together, to ensure a good thermal bond. Tighten the mounting screw firmly, then solder the regulator's leads to its board pads.

The remaining smaller parts can now all be installed. These include trimpot VR1, trimcap VC2 and quartz crystals X1 and X2.

Making the mini oven

The first step in making the oven is to fit the second finned heatsink. Before doing this however, it needs to have a chamfer cut along both inner edges of the two centre fins, to clear the small flange around the bottom of the crystal can – see Fig.7. Basically, you need to remove enough material so that the outer fins rest on the top of the PC board.

A small rotary "hobby grinder" can be used to make these chamfers or you could use a small dental burr or milling cutter.

After cutting the chamfers, apply a small smear of heatsink compound to both sides of the crystal can and to both sides of the centre slot in the heatsink. This ensures a good thermal bond between the two when the heatsink is fitted. It's now just a matter of slipping the heatsink into position over the crystal and soldering its mounting pins to the board pads.

Mini-oven heater transistor Q1 is in a TO-126 package. As shown, it's fas-

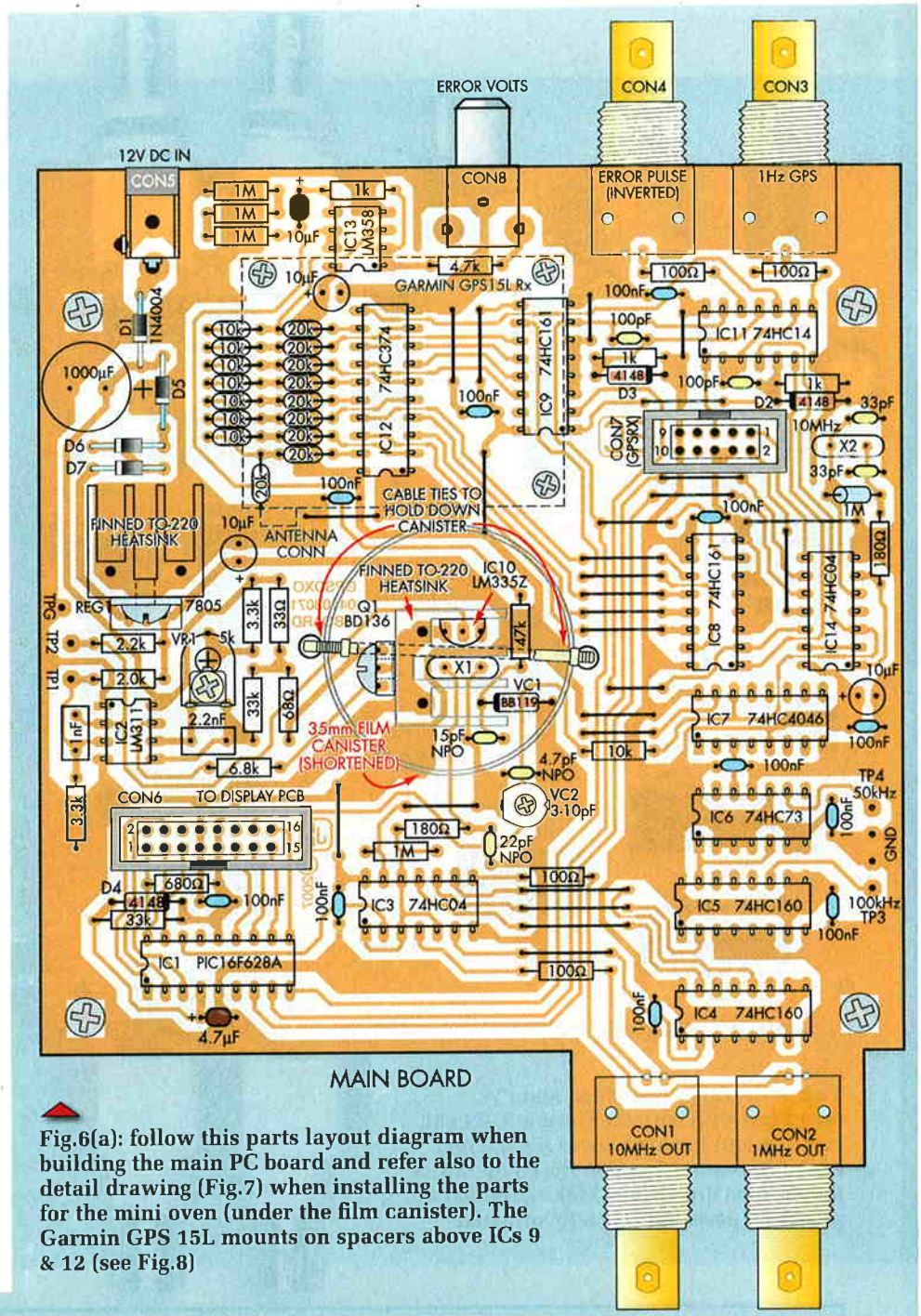


Fig.6(a): follow this parts layout diagram when building the main PC board and refer also to the detail drawing (Fig.7) when installing the parts for the mini oven (under the film canister). The Garmin GPS 15L mounts on spacers above ICs 9 & 12 (see Fig.8)

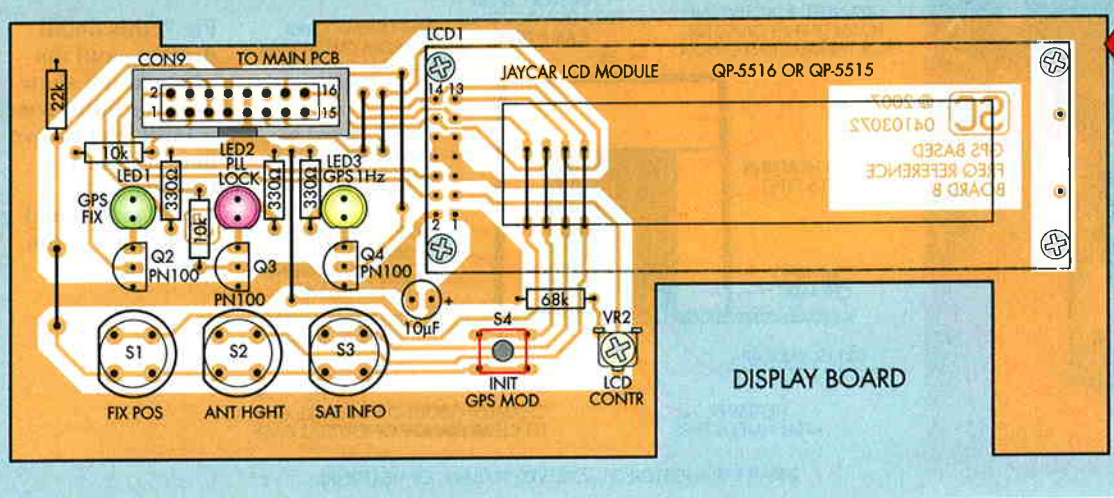
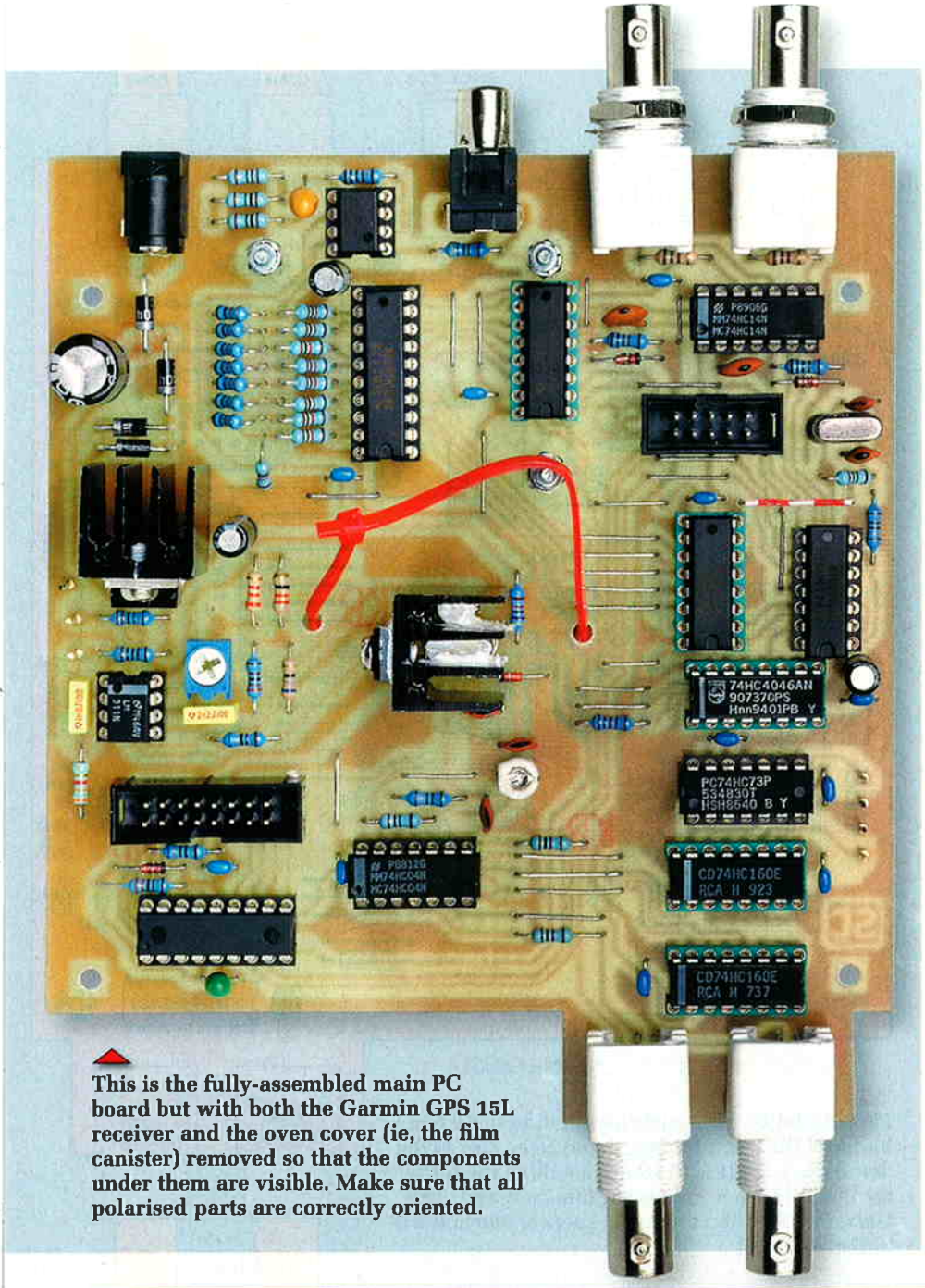


Fig.6(b): assemble the display PC board as shown here. Switches S1-S3 must be mounted with their flat sides as shown, while LEDs 1-3 should sit 11mm above the board surface. Note also that the 10µF capacitor must be mounted flat against the board (see photo).



This is the fully-assembled main PC board but with both the Garmin GPS 15L receiver and the oven cover (ie, the film canister) removed so that the components under them are visible. Make sure that all polarised parts are correctly oriented.

tened to the end of the oven heatsink, again using an M3 x 6mm machine screw. Smear both the transistor and heatsink mating surfaces with heatsink compound before slipping the transistor into position.

Take care with the orientation of Q1 – its metal surface goes towards the heatsink. Don't forget to solder its leads to the board after tightening its mounting screw.

The LM335Z temperature sensor (IC10) is next on the list – see Figs.6 & 7. It's in a plastic T0-92 package and slips easily into place between the heatsink fins. Before doing this though, give it a generous coating on both sides with heatsink compound. That done, slide it down between the heatsink fins so that its body sits about 6mm above the PC board before soldering its leads to the board.

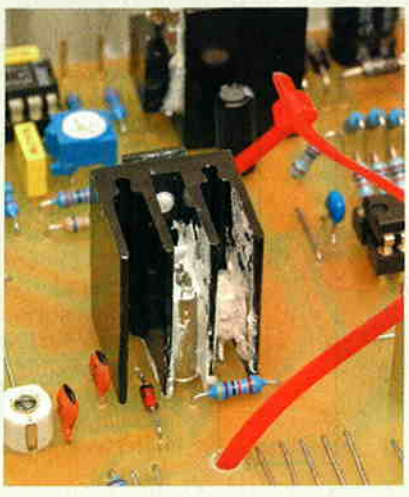
Assuming you've already fitted varicap VC1, its 15pF series capacitor and the 47kΩ isolating resistor, the inside of the mini oven is now complete. All that remains is to fit its outer casing.

This casing is made from a 33mm-diameter plastic film canister (you can get one from a photo processing store) and lined with expanded polystyrene foam sheet about 3mm thick. It's built as follows:

(1) Shorten the canister to about 32mm long, using a pair of scissors or a sharp knife.

(2) Cut a 31mm diameter disc from the expanded polystyrene foam sheet and push it right down to the bottom of the canister.

(3) Cut another piece of the foam into a 28 x 70mm strip and make a series of shallow cuts across the strip on one side, so that it can be rolled lengthwise



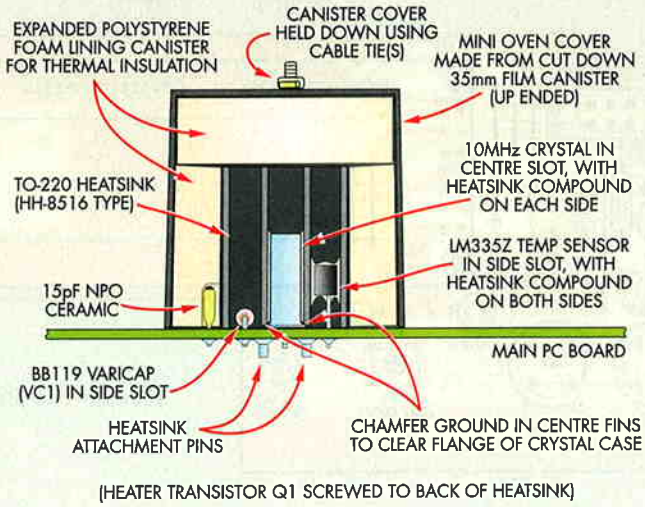
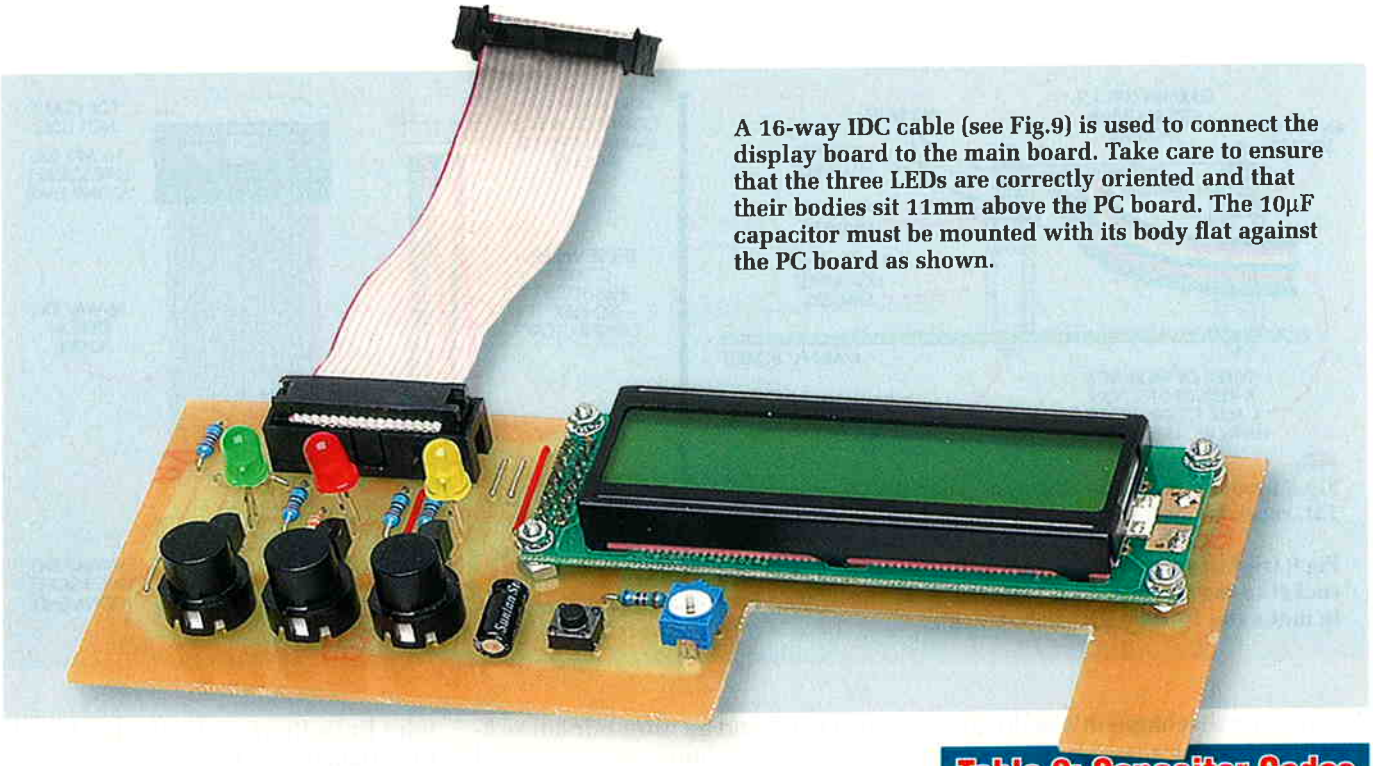

EXPANDED POLYSTYRENE FOAM LINING CANISTER FOR THERMAL INSULATION
CANISTER COVER HELD DOWN USING CABLE TIE(S)
MINI OVEN COVER MADE FROM CUT DOWN 35mm FILM CANISTER (UP ENDED)
10MHz CRYSTAL IN CENTRE SLOT, WITH HEATSINK COMPOUND ON EACH SIDE
TO-220 HEATSINK (HH-8516 TYPE)
LM335Z TEMP SENSOR IN SIDE SLOT, WITH HEATSINK COMPOUND ON BOTH SIDES
15pF NPO CERAMIC
MAIN PC BOARD
BB119 VARICAP (VC1) IN SIDE SLOT
HEATSINK ATTACHMENT PINS
CHAMFER GROUND IN CENTRE FINS TO CLEAR FLANGE OF CRYSTAL CASE
(HEATER TRANSISTOR Q1 SCREWED TO BACK OF HEATSINK)

Fig.7: this detail drawing and the photo at left show how the mini-oven is built. Not shown here is heater transistor Q1 which is fastened to the back of the heatsink.



A 16-way IDC cable (see Fig.9) is used to connect the display board to the main board. Take care to ensure that the three LEDs are correctly oriented and that their bodies sit 11mm above the PC board. The 10µF capacitor must be mounted with its body flat against the PC board as shown.

into a tubular shape. Fit this inside the canister to form the wall lining.

Having lined the canister, the next step is to "up-end" it and lower it down over the mini-oven components on the PC board. Note, however, that you may have to cut a small "pocket" in one side of the foam liner to clear the 15pF capacitor.

Finally, a long plastic cable tie (or two shorter cable ties in series) can be threaded through the adjacent 3mm holes in the PC board and tightened to hold the canister down. The mini-oven assembly is now complete.

Installing the ICs

The next step in the assembly is to install all the ICs. If you've previously installed IC sockets, then it's just a matter of plugging the ICs in, taking care to ensure they are all correctly oriented. Be sure to use the correct device at each location.

Note that most of the ICs are CMOS devices and are easily damaged by

Table 2: Capacitor Codes

Value	µF code	EIA Code	IEC Code
100nF	0.1µF	104	100n
2.2nF	.0022µF	222	2n2
1nF	.001µF	102	1n0
100pF	NA	101	100p
33pF	NA	33	33p
22pF	NA	22	22p
15pF	NA	15	15p
4.7pF	NA	4.7	4p7

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	5	1MΩ	brown black green brown	brown black black yellow brown
❑	1	68kΩ	blue grey orange brown	blue grey black red brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	9	20kΩ	red black orange brown	red black black red brown
❑	10	10kΩ	brown black orange brown	brown black black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	2kΩ	red black red brown	red black black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	3	330Ω	orange orange brown brown	orange orange black black brown
❑	2	180Ω	brown grey brown brown	brown grey black black brown
❑	4	100Ω	brown black brown brown	brown black black black brown
❑	1	68Ω	blue grey black brown	blue grey black gold brown
❑	1	33Ω	orange orange black brown	orange orange black gold brown

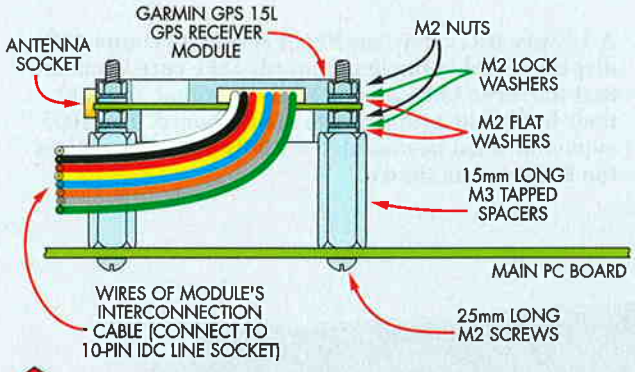


Fig.8 (above): the mounting details for the Garmin GPS 15L receiver module.

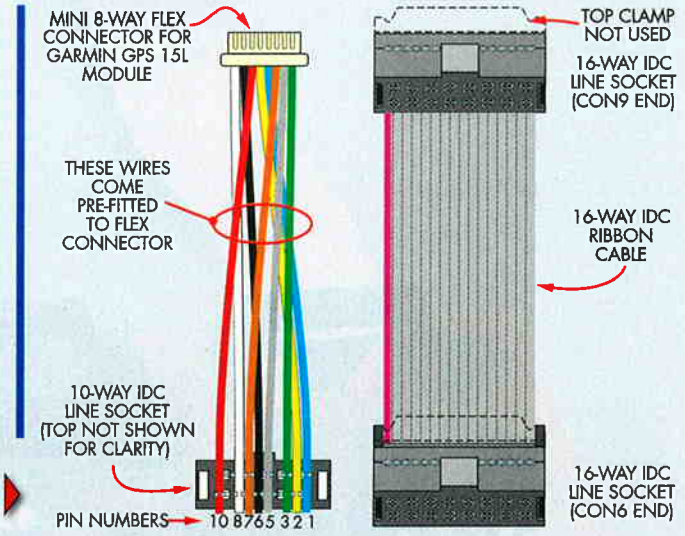


Fig.9 (right): this diagram how to fit the 10-way IDC line socket to the Garmin GPS 15L's cable. It also shows how to make the 16-way IDC ribbon cable.

electrostatic discharge. It's really just a matter of taking a couple of precautions: (1) avoid touching the IC pins; and (2) earth yourself while you're removing them from their packaging and plugging them in (eg, by periodically touching an earthed metal object or by using a wrist strap).

Installing the GPS module

Fig.8 shows the mounting details for the Garmin GPS 15L receiver module. This mounts above the main board, behind the mini-oven assembly and above IC9, IC12, the resistors in the ladder DAC and sundry other parts.

As shown in Fig.8, the module is mounted on three M3 x 15mm tapped spacers and secured using three M2 x 25mm machine screws, together with six M2 nuts, six M2 flat washers and six M2 lockwashers.

Note that the GPS 15L module has a very small female MCX connector for the active antenna lead on one of the longer sides and an ultra-miniature 8-way SIL "flex" connector on one end for all other connections. The module is mounted over the main PC board with its antenna connector facing towards the front and the flex connector end on the right (near CON7).

Once the receiver module has been mounted, shorten all eight wires on the special interconnecting cable supplied with it (ie, with the tiny 8-way flex connector at one end) to about 60mm long. Don't bare their ends though, because they need to be fitted to a 10-way IDC line socket to mate with CON7.

Although IDC sockets are intended for use with ribbon cable, they can also be used with separate light-duty hookup wires of the type used to make the receiver module's cable. The idea is to partly assemble the socket first and then feed the end of each wire through from one side, passing it over the teeth of its connector pin and out the other side.

Fig.9 shows where each wire goes on the connector. Once all eight wires have been fitted, the two halves of the connector are squeezed together firmly in a small vyce, to make the insulation displacement connections. Finally, the top part of the socket can be fitted if you wish and a small cable tie or two used to keep the wires together.

The completed cable can now be connected between the GPS module's connector and CON7.

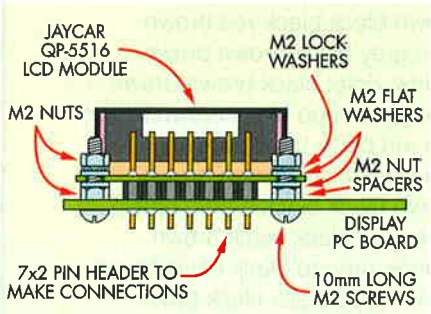


Fig.10: the LCD module is secured to the display board using M2 x 10mm screws, nuts & flat washers.

Display board assembly

Fig.6(b) shows the display board assembly. Begin by installing the nine wire links (four under the LCD module), then install the resistors, trimpot VR2 and the transistors Q2-Q4. Follow these with CON9, the 14-way (7 x 2) pin header for the LCD module, switches S1-S4 and the 10µF electrolytic capacitor. **The latter must lie flat against the PC board – see photo.**

Take care when installing switches S1-S3. Each switch must be seated all the way down on the PC board with its flat side to the left.

The next step is to fit the three LEDs (LED1-LED3). These must be installed with their bodies exactly 11mm above the board, so that they later protrude through matching holes in the front panel. A cardboard spacer cut to 11mm is the easiest way to do this – just push each LED down onto the spacer and solder its leads.

All that's left now is the LCD module. Fig.10 shows the mounting details. Install the four M2 x 10mm screws first and secure them using M2 nuts. That done, place an M2 flat washer on top of each nut, then mount the LCD module is position, making sure it mates correctly with the header pins.

The module can now be secured in position using four M2 washers, four lockwashers and four M2 nuts. That done, the header pins can be carefully soldered to the pads on the top of the LCD module.

Interconnecting cable

You now need to make up a small ribbon cable assembly to connect the two PC boards together. This is made

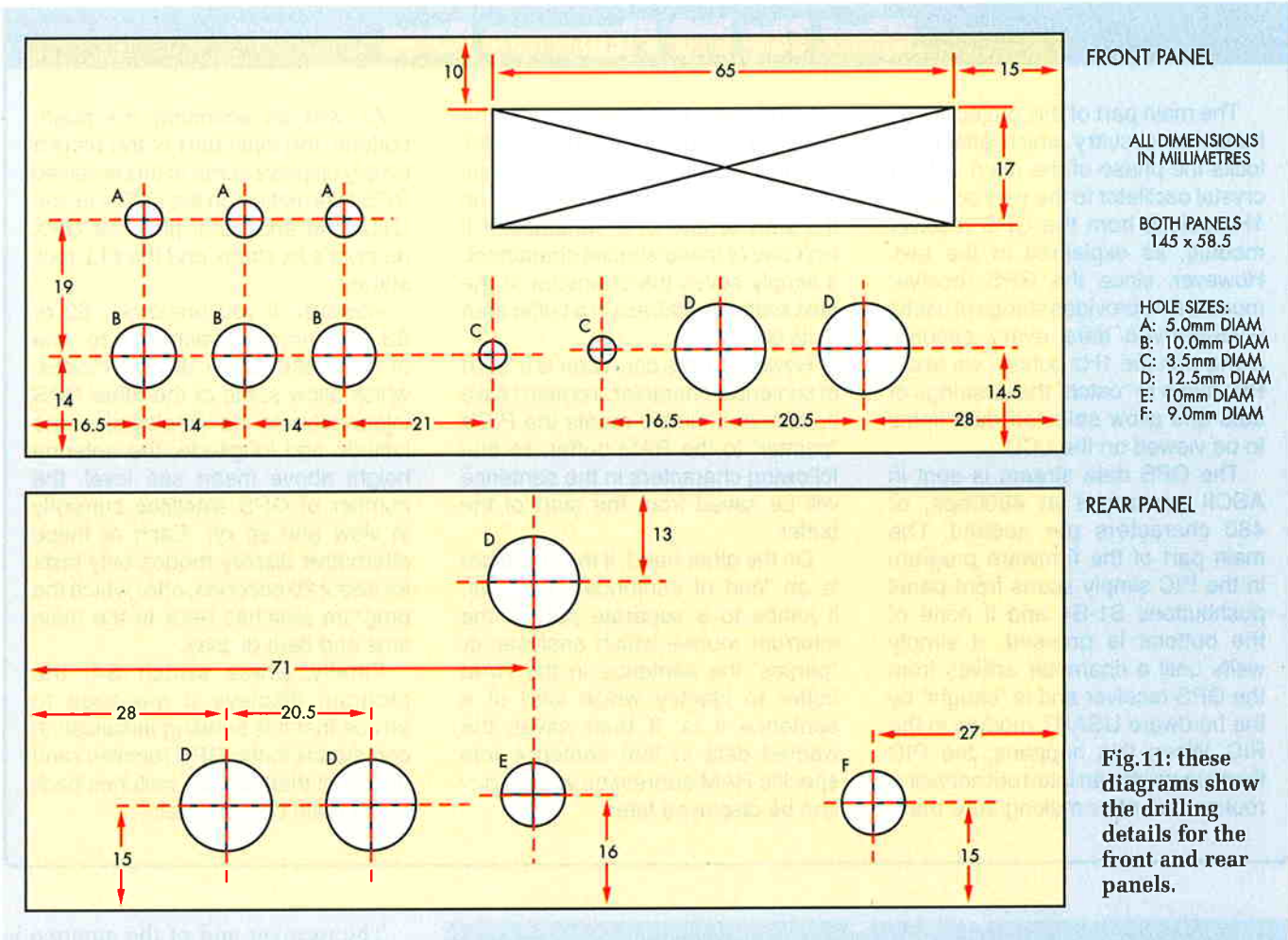


Fig.11: these diagrams show the drilling details for the front and rear panels.

using a 95mm length of 16-way IDC ribbon cable, fitted with a 16-way IDC line socket at each end – see Fig.9. Note that the two sockets both face in the same direction.

Note also that you can't fit the usual top cover to the socket at the display board end, because there isn't enough space for it to clear the front panel. In fact, you may even need to file about 0.5mm from the top of the line socket to provide enough clearance.

You now need to prepare the front and rear panels of the case by drilling and cutting the various holes. These are all shown in the panel cutting diagram – see Fig.11. The 12.5mm diameter hole in the upper centre of the rear panel is used for mounting a BNC female-female panel adaptor. This is used to bring out the GPS receiver module's antenna lead.

Once the panels have been drilled, they can be dressed by attaching the front panel artworks (the relevant file can be downloaded from the SILICON CHIP website and printed out on a colour printer). These artworks are attached using double-sided adhesive tape. Once attached, they can be protected by covering them with clear self-adhesive film (eg, wide sticky tape).

Case assembly

Now for the final assembly. The first step is to loosely fit the front and rear panels to the main board. That's done by removing the nuts and lockwashers from BNC connectors CON1-CON4, then fitting the panels in place over these connectors and refitting the nuts and lockwashers.

Don't tighten the nuts at this stage though. Instead, leave them loose so that the panels can be adjusted.

Having attached the panels, you can now lower the entire assembly into the bottom half of the case, sliding the front and rear panels into their matching case slots as you go. Similarly, the display PC board slides into the third board slot from the front. The main board is then secured to the integral moulded support pillars using the four small self-tapping screws supplied with the case.

The next step is to fit the cable that connects the GPS receiver module to CON7 on the main board. That done, fit the 16-way IDC cable between and CON6 on the main board and CON9 on the display board.

Construction can now be completed by fitting the BNC-BNC adaptor to the rear panel and connecting the internal MCX-BNC antenna cable between this adapter and the GPS receiver module. That done, tighten the nuts on the front and rear panel BNC connectors.

Setup & adjustment

Before doing anything else, you need to install your active GPS antenna. This must be mounted outside and as high as possible, so that it gets an unobstructed "view" of the sky. A good position should be on the top of your TV antenna mast but you may decide on somewhere else because of the need to keep the cable length as short as possible.

What The PIC Firmware Does

The main part of this project is the hardware circuitry which effectively locks the phase of the main 10MHz crystal oscillator to the very accurate 1Hz pulses from the GPS receiver module, as explained in the text. However, since the GPS receiver module also provides strings of useful GPS-derived data every second, along with the 1Hz pulses, we use a PIC micro to "catch" these strings of data and allow selected data items to be viewed on the LCD.

The GPS data stream is sent in ASCII sentences at 4800bps, or 480 characters per second. The main part of the firmware program in the PIC simply scans front panel pushbuttons S1-S4 and if none of the buttons is pressed, it simply waits until a character arrives from the GPS receiver and is "caught" by the hardware USART module in the PIC. When this happens, the PIC then jumps into an interrupt servicing routine and after making sure there weren't any errors, it reads the received character from the USART and then inspects it to see if it has any special significance – such as the start or end of a sentence. If it isn't one of these special characters, it simply saves the character in the next available address in a buffer area in its data RAM.

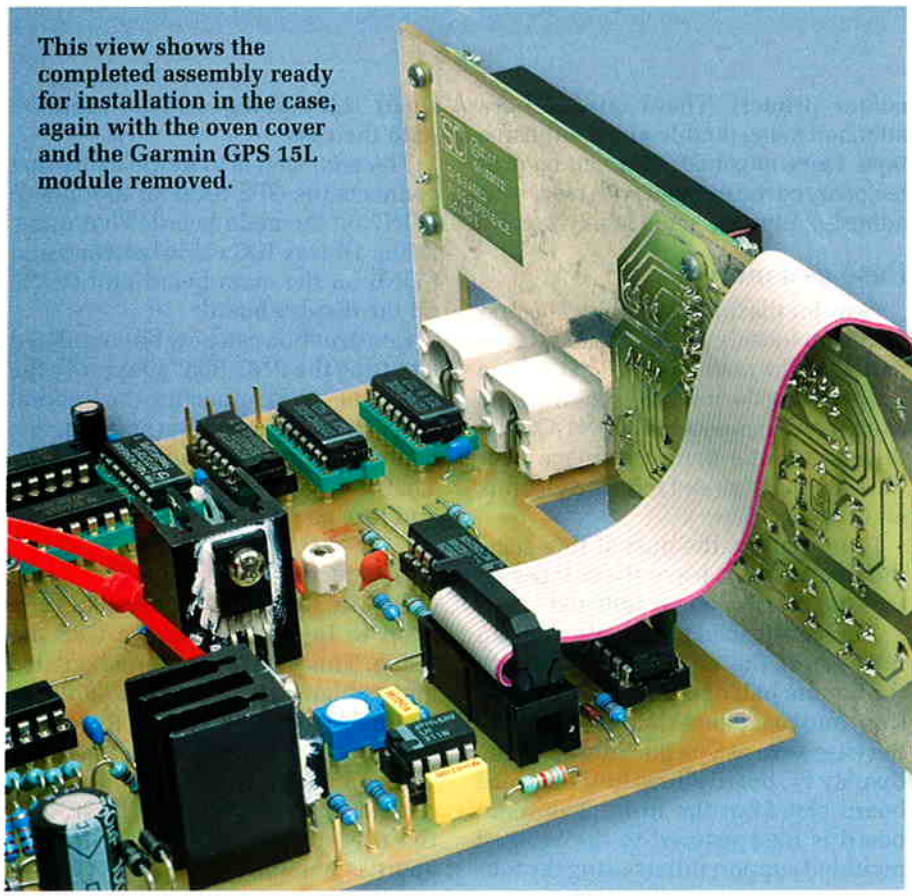
However, if the character is a "start of sentence" character, it doesn't save it. Instead it simply resets the PIC's "pointer" to the RAM buffer, so that following characters in the sentence will be saved from the start of the buffer.

On the other hand, if the character is an "end of sentence" character, it jumps to a separate part of the interrupt routine which analyses or "parses" the sentence in the RAM buffer to identify which kind of a sentence it is. It then saves the wanted data in that sentence into specific RAM addresses where they can be displayed later.

As well as scanning the push-buttons, the main part of the project simply displays some of this received GPS information on the LCD – ie, the UTC time and date, plus the GPX receiver's fix status and the PLL lock status.

However, if you press S1, S2 or S3, the program switches to one of three alternative display modes, which allow some of the other GPS information to be displayed – the latitude and longitude, the antenna height above mean sea level, the number of GPS satellites currently in view and so on. Each of these alternative display modes only lasts for about 20 seconds, after which the program switches back to the main time and date display.

Finally, press switch S4, the program displays a message to advise that it is sending initialisation commands to the GPS receiver (and does just that). It then switches back to the main display again.

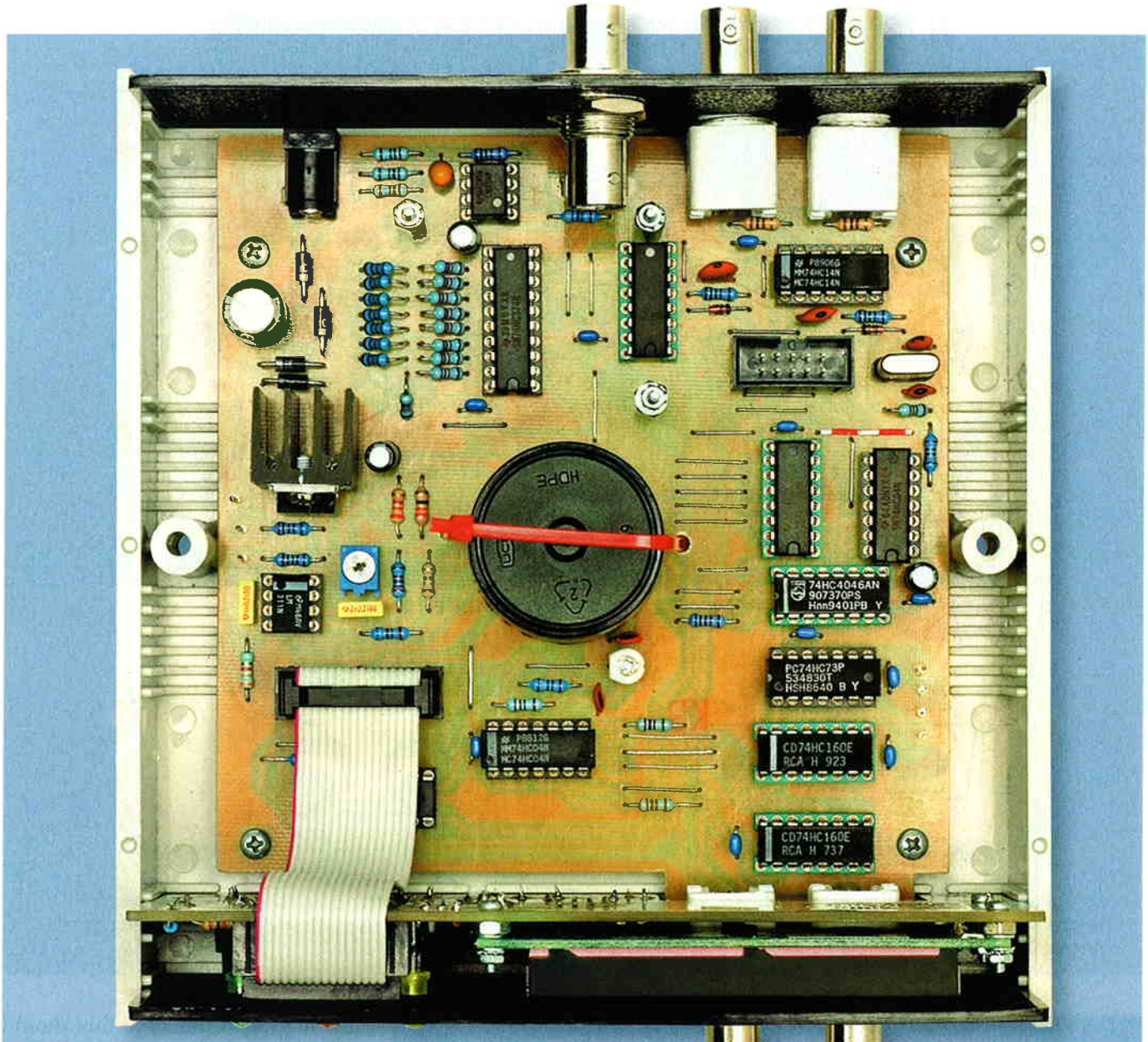


This view shows the completed assembly ready for installation in the case, again with the oven cover and the Garmin GPS 15L module removed.

The receiver end of the antenna is fitted with a BNC plug, to mate with the "outside" section of the rear panel BNC adaptor. Be sure to fit this plug without introducing any short circuits, because this cable carries DC power up to the active antenna (via the GPS receiver module), as well as carrying the GPS signals down to the receiver. A short circuit could damage the GPS module.

Once the antenna is in place, apply power via the DC input socket (CON5). LED2 (PLL Lock) on the front panel should begin glowing almost immediately and you should also be able to measure +5V on the wire link just to the right of IDC header CON6 (relative to the TPG ground pin to the left of REG1). The LCD should also spring to life, although it will probably be showing mainly zeroes for the first 10-20 seconds.

After this time, the GPS receiver module should have found a "fix" and the display should change to show the current UTC time and date, plus a "1" in the upper righthand



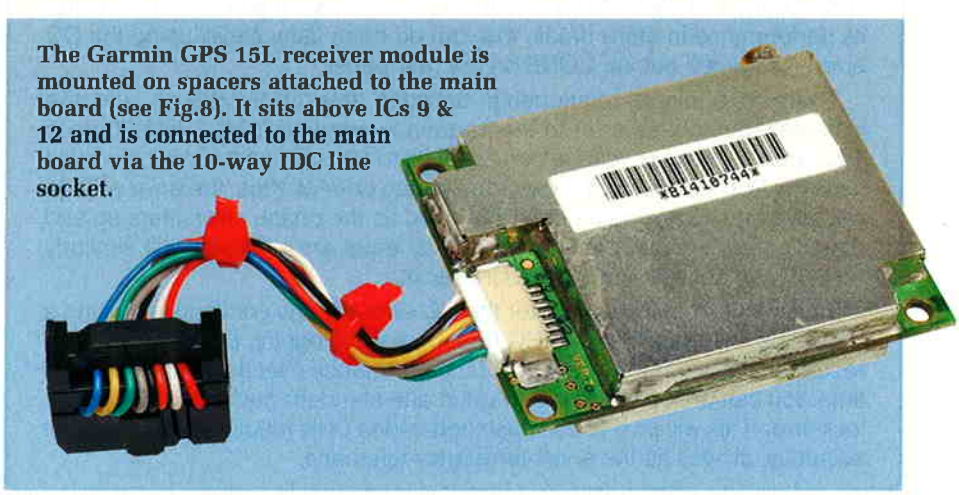
The main PC board is secured to integral spacers on the base of the case, while the display board slides into one of the case slots. Note that the front and rear panels must be attached to the BNC sockets on the main board before mount ing it in the case.

corner to show the fix status. LED3 on the front panel should also begin to blink once per second, showing the GPS 1Hz pulses, while LED1 should also begin glowing continuously to show the fix status.

LED2 may now either be off or it may begin to flash, because the PLL may not be able to lock the phase of the 10MHz crystal oscillator with the 1Hz GPS pulses as yet.

Adjusting the mini-oven

The next step is to check the status of the mini oven's temperature control. First, measure the voltage at TP1 rela-



The Garmin GPS 15L receiver module is mounted on spacers attached to the main board (see Fig.8). It sits above ICs 9 & 12 and is connected to the main board via the 10-way IDC line socket.

This view shows the fully-assembled unit, with both the Garmin receiver and the oven cover in place. Note the internal antenna connection from the Garmin GPS 15L receiver's socket to the BNC-to-BNC adapter on the rear panel (see also picture on facing page).

Monitoring Its Performance

If you're using your frequency reference in a normal workshop/home lab environment, there's probably no need to monitor its performance any further than glancing at its front panel displays from time to time – to confirm that its GPS fix and PLL lock status are both OK. However, if you need to monitor its performance in more detail, this can be done fairly easily using the DC error voltage fed out via CON8 on the rear panel.

There is a direct relationship between this error voltage and the instantaneous phase error in the frequency reference's PLL. In fact, each 19.53mV of this error voltage corresponds to 100ns of phase error, so if you have the PLL stabilised at an average phase error of 10µs, the error voltage will have an average value of 1.953V. And as the phase error jitters up and down in 100ns increments, the instantaneous error voltage will similarly vary up and down in 19.53mV increments.

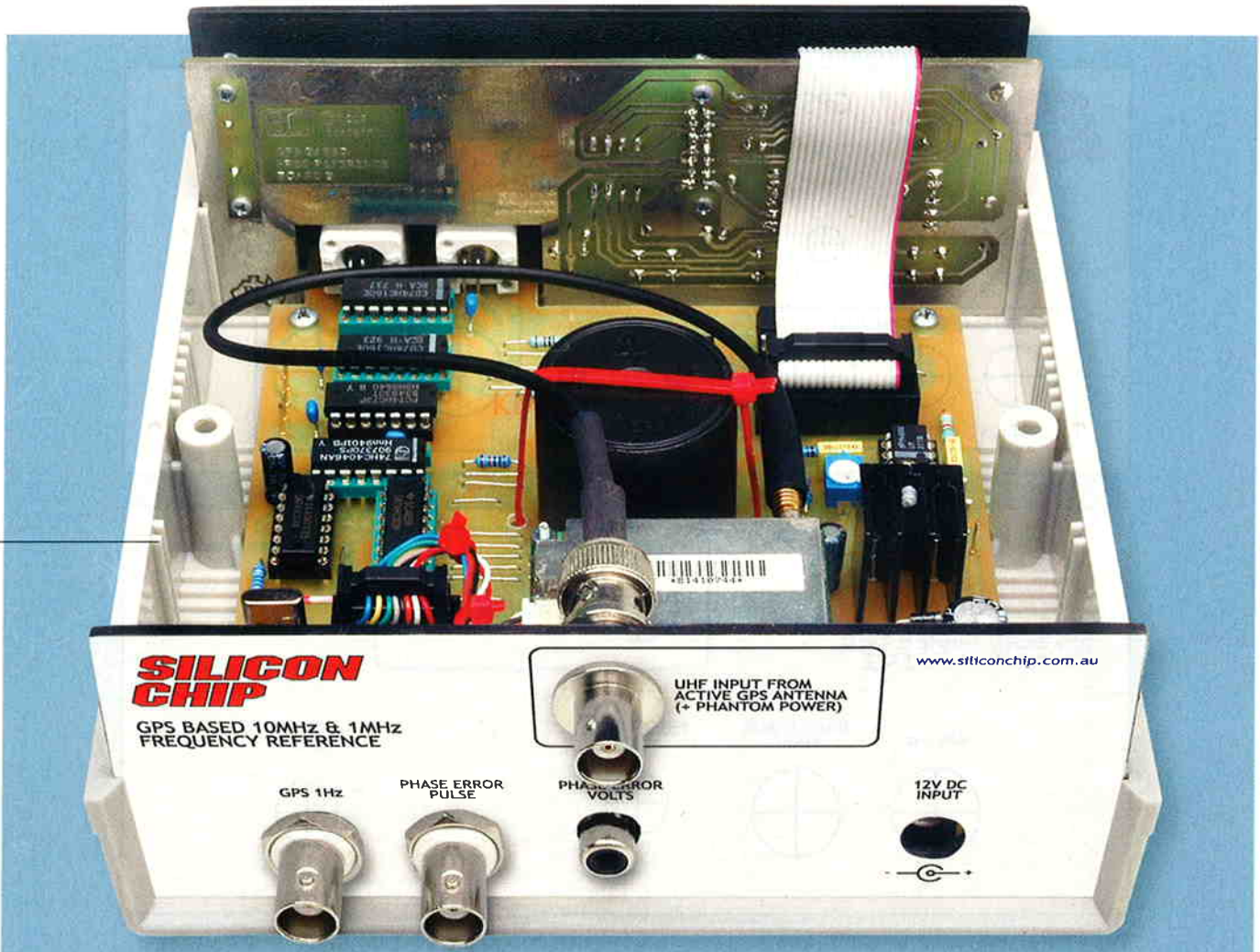
This means that if you monitor the DC error voltage continuously using a DMM and link the DMM to a PC running a data-logging program, you can record the frequency reference's PLL performance over a suitable period of time. You can then plot the mean value and standard deviation of its phase lock error. This will give you a much better idea of its medium and long-term accuracy, as well as the short-term error tolerance.

tive to ground pin TPG; this should measure very close to +3.15V. You should find a similar voltage on TP2 (within a couple of tens of millivolts). This is the voltage across temperature sensor IC10 and reflects the temperature inside the mini oven (3.15V = 315K = 42°C).

If the voltage on TP2 is outside the range 3.14-3.16V, try adjusting trimpot VR1 in one direction or the other until the voltage drifts back inside this range. Don't adjust the trimpot setting in large jumps though, because the temperature changes quite slowly following each adjustment.

Adjusting the PLL

When you are satisfied that the voltage at TP2 is stabilising inside the correct range, you are ready to turn your attention to setting up the 10MHz crystal oscillator and the PLL. For this,



The rear panel carries BNC sockets for the antenna (top, centre) and for the GPS 1Hz and phase error pulse outputs (bottom left). It also carries an RCA socket for the phase error voltage and provides access to the DC power socket.

you will need to use an oscilloscope and a frequency counter.

The input of the scope should be connected to CON4 on the rear panel of the frequency reference, where it will be able to monitor the PLL's phase error pulses (inverted). By contrast, the counter's input should be connected to CON1 on the front panel, where it can measure the 10MHz output signal.

Before you start the setting up, see what frequency reading you are getting on the counter. It should already be quite close to 10.000000MHz, although the exact reading will depend on the calibration of the counter's own timebase.

Now look at the pulse waveform on the scope. What you should see is a negative-going rectangular pulse of 5V peak-to-peak, with a width somewhere between 0µs and 20µs. It may not be fixed in width, though – in fact, if the PLL isn't in lock as yet, it may be cyclically varying up or down in width within the 0-20µs range.

At this stage, try adjusting trimcap VC2, which you'll find just to the front right of the mini oven. Adjust it using a small insulated alignment tool and change its setting by only a very small amount in one direction or the other. As you do, watch the pulse waveform on the scope. If it was cycling back and forth in width, this cycling will slow down if you're adjusting the trimmer capacitor in the right direction.

Conversely, if it speeds up, turn VC2 back the other way until it does slow down. If it wasn't cycling to begin with but does so when you adjust VC2, the same applies – turn it back the other way.

The objective is to carefully adjust VC2 until the error pulse width stops cycling and remains fairly steady at a width of about 10µs. This setting corresponds to the PLL being locked close to the centre of its lock range.

By the way, don't be worried if the pulse width still varies up and down randomly in steps of 100ns (0.1µs). This is normal and is due to propagation jitter on the GPS signals, noise, dither in the PLL as a result of drift in the "about-10MHz" clock oscillator, and so on.

Once you have achieved this stable pulse setting, check the reading on the frequency counter. It should now be reading very close to 10.000000MHz. If you get a reading very close to this, any error you see is almost certainly due to the calibration of the counter's timebase.

The only proviso here is if the counter reading is stable but very close to a frequency that's 200Hz away from 10.000000MHz (ie, 9.999800MHz or

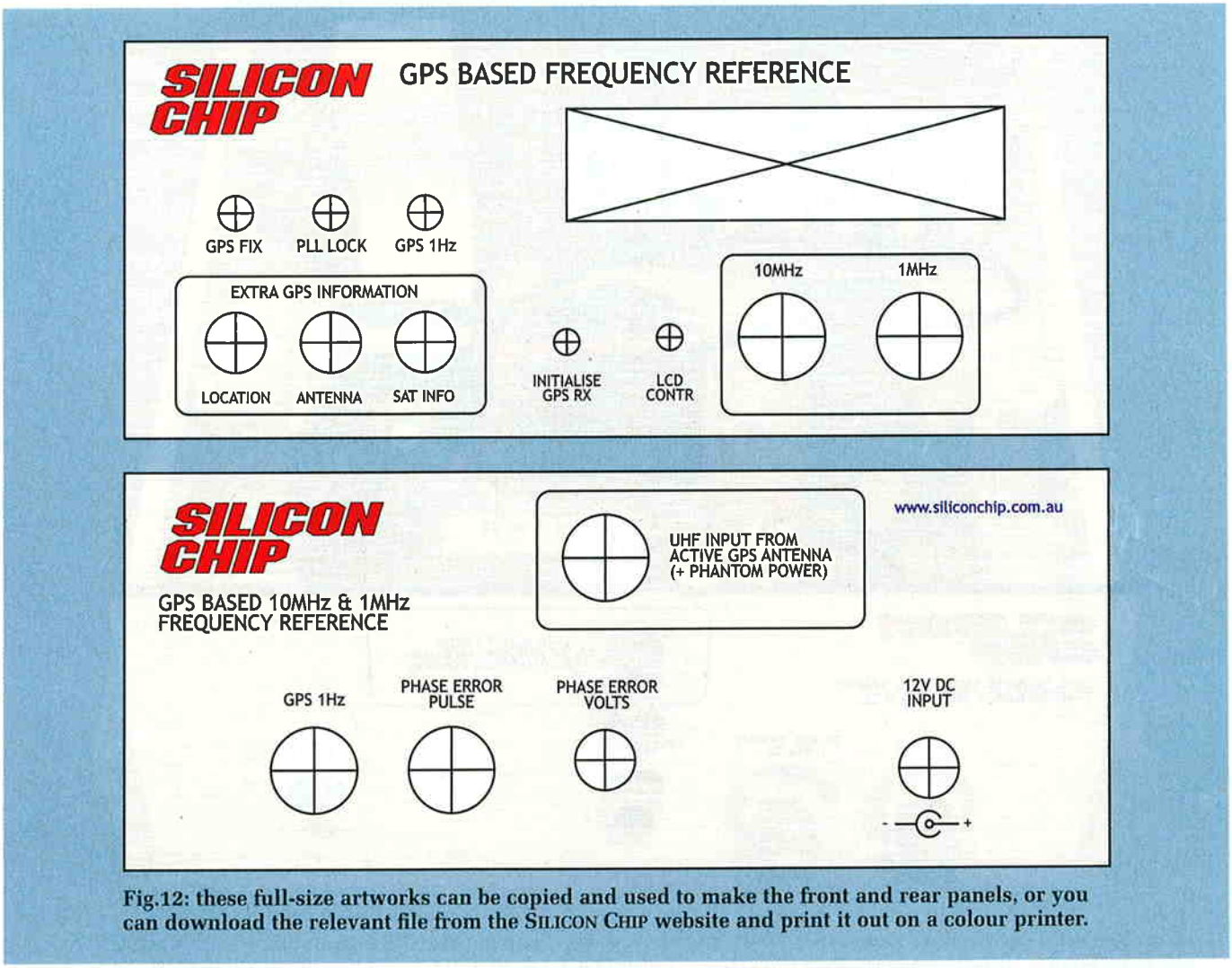


Fig.12: these full-size artworks can be copied and used to make the front and rear panels, or you can download the relevant file from the SILICON CHIP website and print it out on a colour printer.

10.000200MHz). In this case, it means that the PLL is locking quite nicely but to one of those other frequencies. So if you do get a reading very close to these "200Hz-away" frequencies, you'll need to try adjusting VC2 again until the PLL locks at the correct frequency.

If you can't achieve this by adjusting VC2, you will have to replace the 4.7pF NPO capacitor located just behind VC2 with a lower or higher value – depending on which frequency your PLL had been locking at. For example, if it was locking at 9.000800MHz and VC2 couldn't bring it up to 10.000000MHz, replace the 4.7pF capacitor with a 2.2pF capacitor. Alternatively, if it was locking at 10.000200MHz and VC2 couldn't bring it down to 10.000000MHz, use a 6.8pF capacitor.

When your scope shows a reasonably stable phase error pulse (with a width close to 10µs) and the counter displays a reading that's very close to 10.000000MHz, your GPS-Based Frequency Reference should be set up and ready for use. LED1 (GPS FIX) and LED2 (PLL LOCK) should now both be glowing steadily, while LED3 should continue to blink reassuringly once per second. Similarly the LCD should normally show UTC time and GPS fix status (Fx1) on the top line and UTC date and PLL lock status (PLL: L) on the lower line.

Additional information

Additional GPS information is available on the LCD for about 20 seconds if you press one of the three front-panel buttons. For example, pressing S1 (LOCATION) will display the exact latitude and longitude of your external GPS antenna, while pressing S2 (ANTENNA) will display the antenna's height in metres above mean sea level plus the number of GPS satellites currently in view.

Pressing S3 (SAT INFO) displays the identification number of the main four satellites in current view, plus the signal-to-noise ratio of their signals in dB – giving you a good idea of the current GPS "fix" quality.

If your LCD readout isn't very clear, try adjusting its contrast control pot using a small screwdriver through the hole in the lower centre of the front panel. This should give you an easy-to-read display.

Normally, you shouldn't need to initialise the GPS receiver module using switch S4 (accessible via the second small hole in the front panel). However, by all means try doing this if you are unable to set up your frequency reference as described above.

At the very most, this initialising should only be necessary once, because the GPS module normally saves its configuration data in non-volatile flash memory, where it's read whenever the power is applied. SC

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→57

SERVICEMAN'S LOG

Sorting out customer A/V installations

It's not always obvious how you use modern equipment, particularly when there's a menu-driven remote control involved. More and more of our work involves sorting out customer installations but first, here's a story about a rear-projection TV I recently encountered.

Most repairs are either repetitive or have simple solutions, although they aren't always as simple as they once were (thanks to the increasing complexity of modern sets). Obviously, I cannot tell you all the stories about blown fuses or easily-diagnosed transistor failures, as you would fall asleep. As a result, I try to keep to the stories that are interesting (hopefully) or have a twist in them.

A good example of the latter was the rear-projection TV that came in with a colour purity problem. A purity error refers to a spurious colour patch and in CRT sets, you adjust the yoke in and out and rotate the purity ring magnets so that the screen is filled with only one colour, as selected on a pattern generator.

Normally, you do this in turn for Red, Green, Blue and finally, White. However, before proceeding, you first make sure that the set is degaussed and is correctly aligned to the Earth's magnetic field. It must also be well away from all other sources of magnetism.

The rear projection set in question was a 2003 Philips 43PP9251/79 using an A10 PTV 2.0 chassis and it had a colour patch in the bottom righthand corner. But how could this happen? The set uses three dedicated CRTs (red, green and blue) and there is no purity adjustment as none is necessary.

This set had obviously had a hard life and came in with a dreadful picture. The convergence was shot and the picture quality was dull, the blue and green colour saturation both being particularly poor. Two new convergence ICs fixed the convergence problem after which a vain attempt was made to adjust the G2 screen voltages before it was realised that the CRTs themselves were to blame.

You couldn't actually see the problem until you removed the screen and mirror and looked into each lens. The blue and green in particular had algae growing in them and the fluid had turned a murky yellow.

Basically, there are two ways to change the fluid – the "hard way" and the "easy way". The former is what Philips recommends and this involves removing each CRT, disassembling the whole thing and removing the complete lens assembly. You then fit new gaskets after cleaning the screen face, pour in the new fluid and then reassemble them before doing major realignment.

The easy way is to raise the corners of the cabinet until the CRT you are working on is dead level. You then undo four inverted star screws (a 6mm spintight will do) and remove just the lens. During this process, it is absolutely essential to pack lots of rags tightly around the CRT face and underneath it to prevent any liquid spillage from dropping onto the PC boards below.

Usually, when you remove the lens assembly, the rear lens remains stuck to the CRT gasket, with the lens dome submerged in the liquid. This is fine because you can then concentrate on removing this final lens swiftly and cleanly, without causing any fluid to overflow.

Next, using a pipette or syringe, you remove the remainder of the liquid before using Windex to clean off the caked algae and dirt stuck on the CRT screen. You then pour the new liquid in using a funnel, being careful not to overfill as subsequently replacing the lens would then cause it to overflow.

With patience and care, you can do this quite easily and the beauty of it is there is no realignment necessary.

Of course, when I did it, things took a slightly different turn – for the worse, of course. First, the red gun lens

Items Covered This Month

- Philips 43PP9251/79 rear projection TV (A10 PTV 2.0 chassis)
- NEC FS8002 TV set
- Philips 32PW8806/79R TV set (MG2.1E chassis)
- Sanyo CP32WF2-00 TV set (EB7-A chassis)
- Sony KV-ES29M31 TV set (AG3 chassis)
- Teac PLH4220 SD/4942 plasma set

I HAD TO GO INTO HOSPITAL FOR AN OPERATION...

decided to stick to the lens assembly rather than to the CRT, so the liquid overflowed and somehow managed to miss the rags and fall directly onto the new convergence ICs. That meant removing the board and cleaning it very carefully. However, it still managed to ruin a PNP transistor which switched the -30V rail to the IC, causing all sorts of weird blue convergence errors.

When the lens was refitted, the fluid again overflowed but I managed to clean up the excess without incident this time. I was pretty confident that all was OK until confronted with a purity error.

It took a while to realise what was happening. When the set is level (ie, in its normal operating position), each CRT gun is angled – particularly the red and blue guns. And although I thought they were full of liquid, a slight air bubble was in fact appearing on the edges of the red and blue gun lenses in the normal position.

This time I turned the whole cabinet over and aligned it until the filler nuts were uppermost. That done, I removed the nuts in turn and filled them right up. This was not quite as simple as it sounds, as one gun (the blue one) was for some reason 180° different from the other two. Fortunately, when the job had been completed, the purity error had been eliminated.

Finally, the greyscale needed aligning but I ran into problems at one stage when I got the A2 adjustment wrong. This resulted in the set refusing to start and setting off a protection circuit which left the Standby LED flashing.

When the job was completed, the picture wasn't too bad, even though there was a bit of screen phosphor burn on each of the CRTs.

It's not obvious

It's not always obvious how you use a lot of modern equipment. For example, some TVs and DVD players have very complex menu systems. And if a language like Chinese or Korean is already selected, then how do you figure out how to change it back to English?

Recently, I had a Sharp LCD TV where the customer was unable to select the DVD input. When I arrived at his house, he demonstrated the problem. He picked up the remote, switched the set on and then pressed the DVD button. He then pointed to the screen which clearly showed a "DVD" window in the middle. But then nothing else happened – certainly nothing in the way of video or sound was coming from the DVD.

Well of course I had never seen this particular TV before so I started by making sure that all the connections were kosher, which they were. My client became a little disconcerted when I hadn't discovered the problem in the two minutes I had been there and became even more concerned when I wanted to see the instruction book. Obviously I didn't know anything if I had to consult a "map"!

Frankly, I'm a great believer in the old adage that when all else fails, read the book. If that fails, you get a guide to the instruction book from the manufacturer!

The disturbing thing about most instruction books – like remotes – is

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that they are physically small, with hundreds of pages and a really poor index. Eventually, however, the penny dropped. The remote control unit was a type that could be programmed for other items or accessories. It could be made to operate a VCR, an amplifier or, in this case, a DVD player.

So despite its prominence on the front of the remote, the DVD button wasn't the button to press. Instead, there was another button next to it with a symbol showing an arrow pointing into a TV screen. This was the button to use, as it sequentially controlled the AV inputs into the set. Selecting DVD with this produced the desired picture and sound.

OK, so that was fairly obvious. The next one I had concerned a guy who had a large NEC FS8002 CRT TV and when ever he selected DVD, the picture was in black and white though the sound was OK.

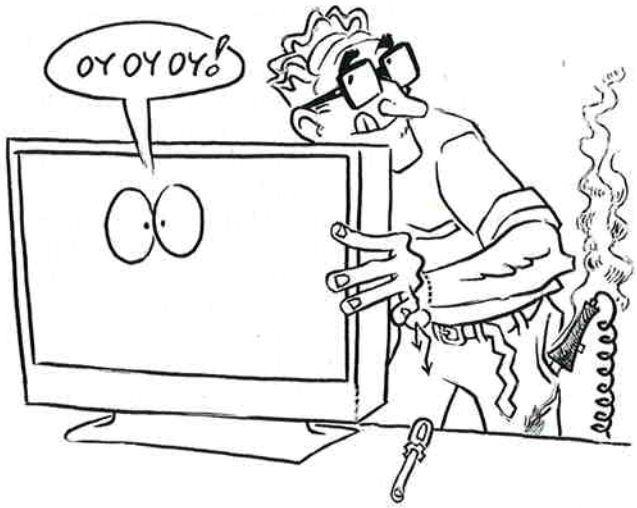
Now I had originally installed this set and knew that it was OK the last time I had seen it (about a year ago). Subsequently, I had to go into hospital for an operation – no, not a lobotomy – and during this time, the customer called about something else.

However, I didn't know anything about this until I arrived to sort out his "black & white on DVD" problem. Apparently, he had called in another technician when he found out that I was in hospital – one who was much more "savvy" than I. This technician had flogged him a Digital Set Top Box (DSTB) and installed it, which was smart thinking money-wise – at least from the tech's viewpoint. The only thing was that they could already get all the stations they wanted via Foxtel Digital, so they didn't need the DSTB.

Unfortunately, if my opposite number had left any instructions on how to use this, he hadn't done it in writing and the elderly owner had no idea how to use it.

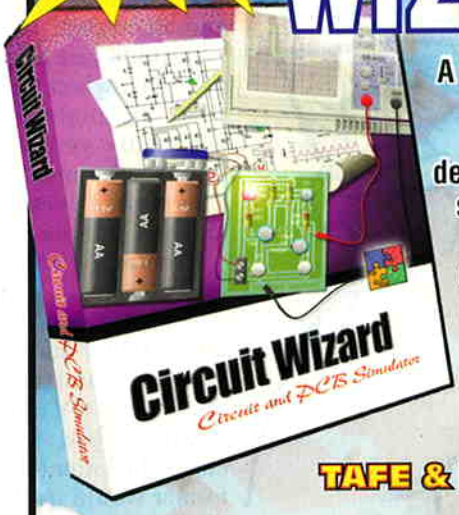
Anyway, I studied the manual for his TV and checked all the connections. I also made sure that the input menu was set for AUTO or PAL but I was going nowhere.

When you pressed the Input button on the remote, it sequentially cycled TV (free-to-air), AV1 = Foxtel and Combo, AV2 = DSTB, AV3 = not used and DVD. All gave



~I STARTED BY MAKING SURE THAT ALL THE CONNECTIONS WERE KOSHER

NEW! CIRCUIT WIZARD



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Q6805'S COLLECTOR WAS VERY HIGH

colour except the DVD input. So what was going on?

It took a very long time for my brain to twig what was happening. In fact, there was nothing wrong at all. This TV set was just unusual and shared inputs AV1 and DVD. AV1 used the usual Yellow, Red and White leads (ie, composite video and left & right audio), while the DVD input required RGB signals (plus the left and right audio signals).

To match his DVD player, all he had to do was select AV1 on his TV and change the combo from VHS to DVD (AV1). The only thing he shouldn't do was select the DVD input on the TV. Weird, eh?

Another schemozzle

Last month, I was carrying on like a two-bob watch about error codes and this month I got embroiled in yet another schemozzle. It concerned a 2000 Philips 32PW8806/79R TV set (MG2.1E chassis) that was intermittently not starting.

When I did manage to get it to go, I put it into the SAM mode (Service Alignment Mode) as soon as possible and checked out the error codes. These were 67 and 68 which refer to the +8V and +5V supplies respectively.

However, when I cleared the error buffer and did a functional test, no further codes came up. The set then worked perfectly, even switching on and off correctly with the remote.

It didn't last long because the very next day, when switching it on from cold, the problem was back. After eventually getting it going, I went through the above procedure again. This time, I even measured the +5V and +8V rails as being spot on.

Eventually someone whispered in my shell-like . . . "it's the relays".

In fact, there are two 5V 10A IP relays (1002 and 1010), one for the degaussing and the other for switching the main +330V rail to the switchmode power supply. The quickest way to check the latter (it is unlikely that the former would be the cause, being the degaussing circuit) was to short out the relay switch contacts and then test it.

Well, much to my surprise, that fixed the problem! To further confirm it, I swapped the two relays around and noticed that the purity was now slightly out (indicating that the degaussing was no longer working correctly). However, the original fault did not reoccur, so I ordered and fitted two new relays just to be sure.

The relays are sealed units so you can't see inside them but it's almost certain that the contacts were worn in the unit that switched the +330V supply rail.

It just goes to show you can't always believe error codes.

DOA Sanyo

A wide-screen Sanyo CP32WF2-00 (EB7-A chassis) arrived on my bench DOA (dead on arrival).

The power supply was blown. As usual, I replaced chopper transistor Q613 (2SC4429), driver transistor Q612 (2SC3807) and the main B+ (330V) feed resistor (R602, 1.8Ω 5W). This fixed the power supply but when the picture came on, the set would immediately close down.

The B+ for the line output stage was spot on at +150V and the other supply rails looked OK too. As a result, I decided to check the protection circuits, starting at pin 11 of microprocessor IC801. This should have been at +5V but was in fact down to +4.5V.

I followed the protection lines back to their diode detectors but could find no reason why this voltage was low, even when I disconnected them one at a time. I then tried asking Sanyo Technical Support and the technician there suggested that either crystal X801 and or X231 might be off frequency, so I changed them – to no avail.

When I had disconnected the +200V rail protection, it took much longer for the set to close down. Thinking that this might be a clue, I subsequently spent a lot of time investigating this protection circuit before finally abandoning the theory.

Next, I tried hooking pin 11 up to the +5V rail via a 100kΩ resistor. When this happened, the set came on and stayed on with a good picture and sound. It was then that I noticed that the +5V rail was now high at somewhere between +8V and +9V. I had actually measured it before and I promise you, it was then spot on 5.0V!

This brought Q646 (2SC3807), the 5V regulator, to my attention. I removed this transistor and tested it but it looked OK, even with a Peak Transistor Analyser. However, a new transistor fixed the problem completely – the +5V rail was now correct (and stable) and the set stayed on.

Interestingly, the protection rail is apparently measured by the CPU at pin 11 and triggers if it goes below 5V. Even a 0.5V drop is enough to turn the set off. It seems to me also that it measures it in relation to the +5V rail and not ground.

Non-starting Sony

I was invited by a colleague to assist in the repair of a 1999 Sony KV-ES29M31 employing an AG3 chassis. The set wouldn't start, initially flashing the green LED four times and then red LED four times before reverting back to Standby.

The Green LED denotes the number of times the set tried to start, while the Red LED indicates error code 6 which denotes horizontal deflection failure. The probable cause of this is that C6831 (8.2nF) across the line output transistor has gone open circuit. As a result, the horizontal output pulse is going too high and setting off the protection circuit.

However, in this case, the capacitor measured fine but we still fitted a new one. We also checked the capacitors all around it. The service manual also

mentions connector CN6101 to the D1 board can also cause this symptom if it is disconnected.

Next, we checked all the usual suspects around the line output stage and even changed the flyback transformer without result. We then began to realise that we didn't really understand what we were doing and were just checking things in an ad-hoc manner.

We started again and noted that at no time did we hear the EHT static, which suggested that contrary to the error code, the line output stage never really got going. We measured +135V to the line output and PIN OUT transistors and their drivers but only one was actually switched on.

Q6805's collector was very high, implying that there was no drive signal. We traced this back through CN1162-13 from the D Board to the A Board and then from CN1140/4101-4 to the E Board. The E Board is a small, almost inaccessible, vertical module with many surface-mount components. Without expensive extension leads, it would be impossible to scope the waveforms through it.

Using an ohmmeter, we found that surface-mount transistor Q4808 (2SA1037) on this board – the horizontal pre-driver – was open circuit. We replaced this with a BC857 which is similar general-purpose transistor but despite our optimism, it didn't fix the fault.

By now, we had spent too much time on the problem, so we decided to fit a new E Board. That fixed the problem but it was disappointing that we didn't find the precise cause of the fault.

Dead Teac

I was called out to a dead 2-year old Teac PLH4220 SD/4942 plasma set. This time, I remembered to bring my special large piece of cardboard with spaced sponges glued onto it.

When I got there, the customer helped me lift this 106cm set and lay it face down on the sponges. I then used my electric screwdriver to undo the numerous screws in order to remove the back before checking the fuses using an ohmmeter.

The important thing to remember here is to check the fuses outside their holders as there are diodes strapped across them on the PC board. I soon found that the fuse on the Y SUS Board had failed, indicating further problems on this board.

This set is basically a re-badged LG and the Y SUS, Z SUS and CONTROL boards are a matched set. As a result, no attempt should be made to repair these boards to component level. Fortunately, the replacement boards were surprisingly cheap and had been updated by the factory.

I fitted them and checked the voltages before replacing the back and stand. And that was it – problem fixed. SC

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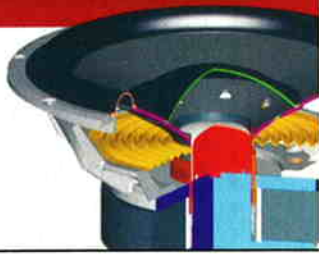

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.

Optical water level switch

Here's a novel approach to detecting water level. It uses a photodiode glued to the rear of a LED as the detecting element.

The principle of operation can be demonstrated by observing the light from the rear of an ordinary red LED. When the tip is dipped in water, the light level emitted is significantly reduced. This circuit uses an infrared LED to reduce the effects of ambient light, although it will still need to be shielded from bright light.

An infrared photodiode acts as the light detector. It is wired in series with a current-limiting resistor and is reverse-biased in dark conditions. When sufficient light strikes the photodiode, it begins to conduct, causing an increasing voltage at the non-inverting input (pin 3) of op amp IC1.

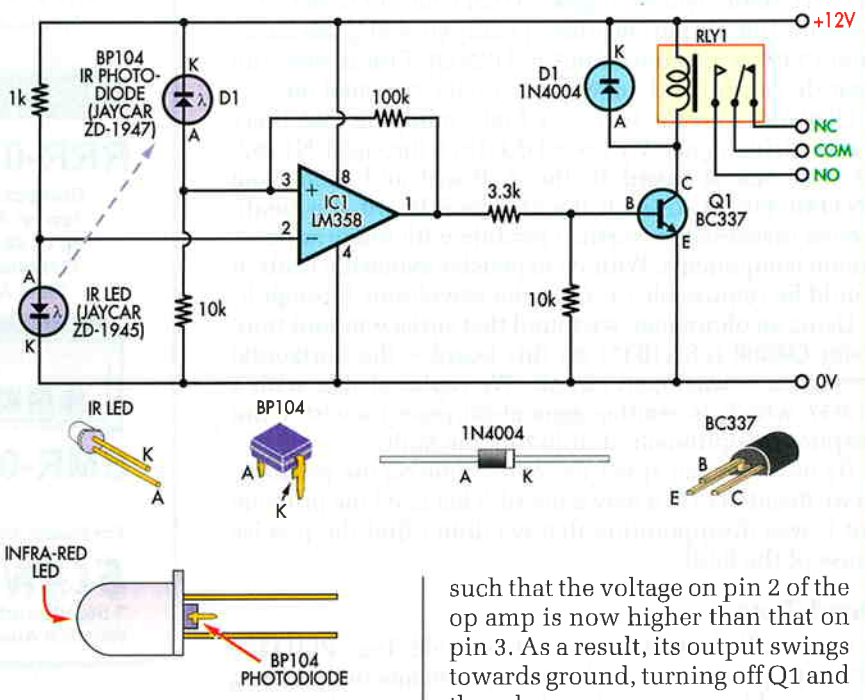
The op amp is wired as a voltage comparator and has about 1.2V on its non-inverting input (pin 2), which is conveniently sourced from the anode of the LED.

Until the tip of the LED is immersed in water, the photodiode is conducting, holding the voltage at pin 3 higher than pin 2. In this condition, the op amp's output if driven towards the positive rail, switching on Q1 and energising the relay.

When the water reaches the LED, photodiode conduction is reduced such that the voltage on pin 2 of the op amp is now higher than that on pin 3. As a result, its output swings towards ground, turning off Q1 and the relay.

As mentioned, the diode is glued to the rear of the LED. A felt-tipped pen housing can be used to contain the probe assembly, allowing all electrical connections to be completely water-proofed.

Phillip Foote,
Dianella, WA. ($35)

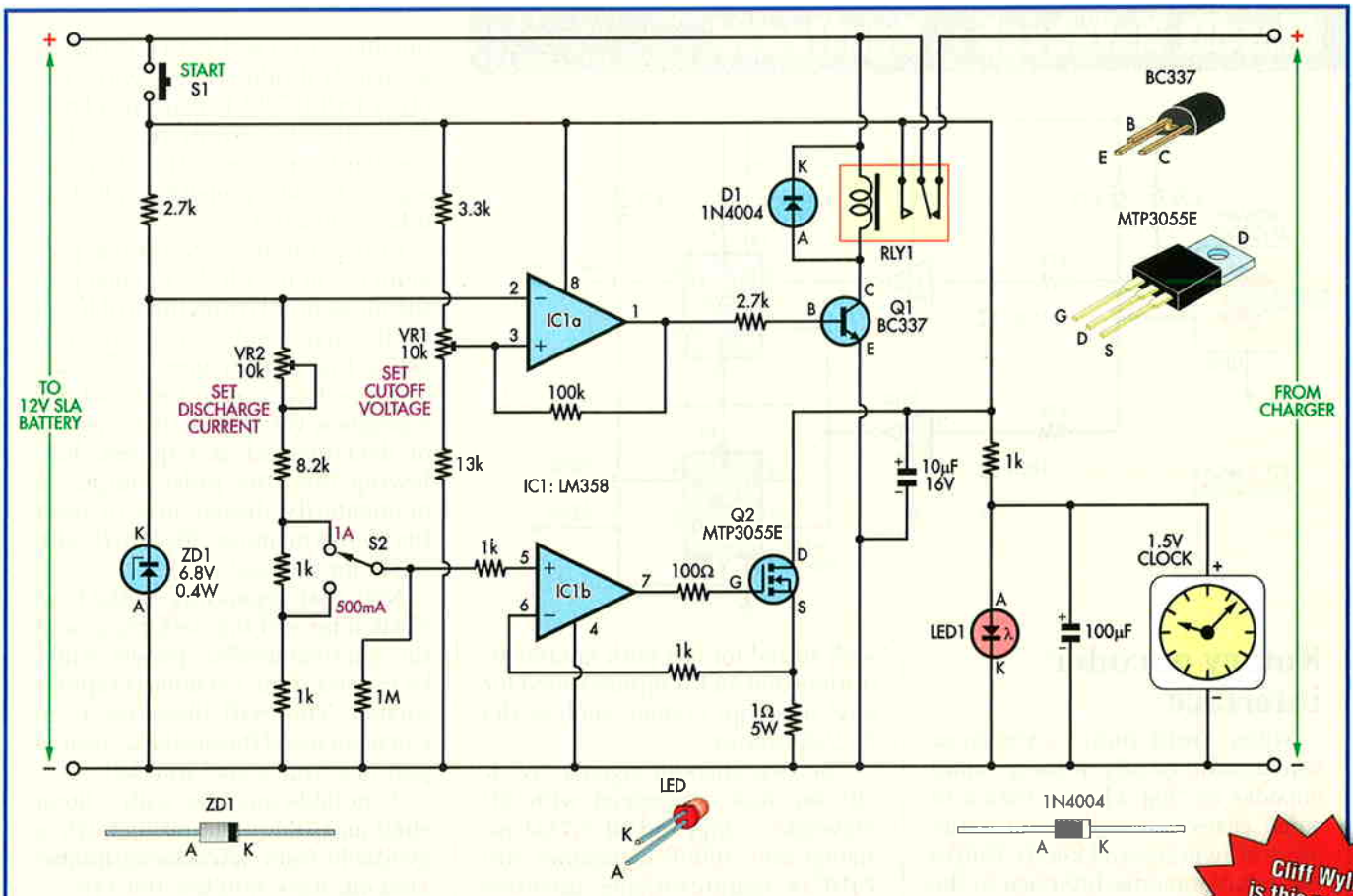


Contribute And Choose Your Prize

As you can see, we pay good money for each of the "Circuit Notebook" items published in SILICON CHIP. But now there are four more reasons to send in your circuit idea. Each month, the best contribution published will entitle the author to choose the prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser, an ESR60 Equivalent Series Resistance Analyser or an SCR100 Thyristor & Triac Analyser, with the compliments of Peak Electronic Design Ltd **www.peakelec.co.uk**

So now you have even more reasons to send that brilliant circuit in. Send it to SILICON CHIP and you could be a winner.

You can either email your idea to silicon@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.



12V SLA battery capacity tester

Here's a relatively simple circuit that can be used to test the capacity of 12V SLA batteries. It's powered from the battery under test and uses a standard 1.5V quartz clock to indicate discharge time.

Circuit operation is initiated by pressing the "Start" switch (S1), which connects battery power to the circuit. Assuming that the battery voltage is above the programmed cut-off voltage, the output of op amp IC1a immediately swings high, switching on Q1 and pulling in relay RLY1. An alternative power path now exists via the relay contacts, so the circuit remains active when the Start switch is released.

IC1a is wired as a voltage comparator with a 6.8V reference applied to its inverting input (pin 2). This is sourced from a simple shunt regulator formed by zener diode ZD1 and its 2.7kΩ series resistor.

The voltage on IC1a's non-inverting input (pin 3) is adjustable via trimpot VR1 and when this drops below the reference voltage, the output (pin 1) swings low. This in turn switches off transistor Q1 and the relay, removing power from the circuit and terminating the discharge.

Op amp IC1b operates as a voltage follower. It attempts to maintain the voltage at its inverting input (pin 6) – and hence the voltage across the 1Ω sense resistor – equal to the reference voltage on its non-inverting input (pin 5). In conjunction with Mosfet Q2, this configuration yields a constant-current sink.

Toggle switch S2 allows selection of either a 0.5V or 1V reference voltage, corresponding to 500mA or 1A of discharge current, respectively. After initial construction, select the 1A range and adjust VR2 for precisely 1A of battery current, as measured on a DMM.

In addition, VR1 should be set to the correct discharge end voltage for the selected discharge rate, as specified by the battery manufacturer. For example, a 12V 1.3Ah Panasonic VRLA battery would be discharged to a minimum of 9.8V on the 1A setting, which equates to a 0.77C discharge rate. The larger 7.2Ah Panasonic unit would be discharged to a minimum of 10.5V on the 1A setting.

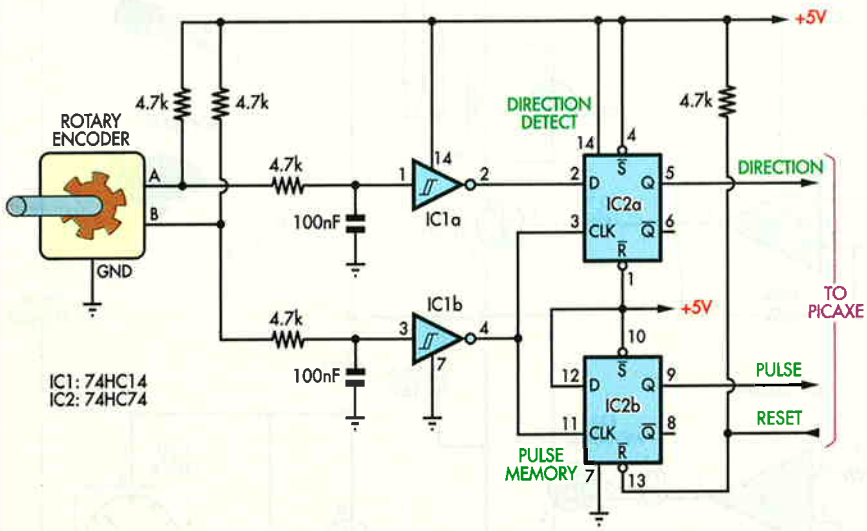
The discharge time is read off the quartz clock, which is powered from the circuit rather than its usual internal 1.5V cell. A standard red LED acts as a simple shunt regulator for the clock, ensuring that no more than about 1.9V is applied to the 1.5V mechanism. The LED flashes each time the clock pulses, which is also a good indication that the system is operating.

In use, the clock is first set to 12:00 and then the discharge current selected. It's then just a matter of pressing Start, after which the battery will be discharged until the cut off voltage is reached. At this point, if a charger is connected, the battery will be recharged. The clock indicates the number of hours taken for the discharge at the set rate.

Note that if testing high-capacity batteries, the discharge time may exceed 12 hours – keep an eye on the clock. Alternatively, the circuit could be modified to support higher discharge rates.

Cliff Wylie, Camden, NSW.

Cliff Wylie is this month's winner of a Peak Atlas Test Instrument



Rotary encoder interface

Many front-panel interfaces can benefit greatly from a rotary encoder or "jog wheel", which in some cases can replace an entire array of switches and knobs. Unlike the rotary encoder interface in the May 2006 issue, this design uses a hardware-assisted approach and is well suited for use with microcontrollers that lack a sophisticated (or any) interrupt system, such as the PICAXE series.

The two encoder signals "A" & "B" are first debounced with RC networks comprised of 4.7kΩ resistors and 100nF capacitors and 74HC14 Schmitt-trigger inverters (IC1a & IC1b). The direction of rotation is determined by "comparing" the phase of A & B with one half of a 74HC74 flipflop (IC2a), while the other half (IC2b) is used as a latch to capture the narrow pulses. The resultant pulse and direction and signals are interpreted by a PICAXE microcontroller.

In use, the microcontroller program (ie, in the PICAXE) must poll the pulse input (from pin 9 of IC2b) until a high level is detected, indicating that the encoder is rotating. The direction input is then read and a program variable is incremented or decremented as required. Following this, the pulse output is momentarily driven low to reset the "pulse memory" flipflop (IC2b), ready for the next pulse.

Note that depending on the type of encoder and the performance of the microcontroller, pulses might be missed if the encoder is rapidly rotated. This will likely be of no consequence if the design is used as part of a front-panel interface.

A suitable encoder with a 6mm shaft and 10mm mounting bush is available from **www.farnellinone.com.au**, stock number 109-113.

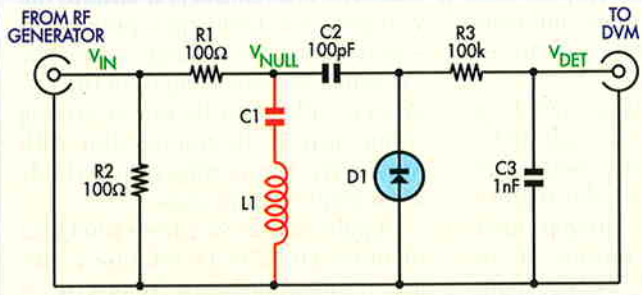
Keith Bolton,
Hobart, Tas. ($35)

Measuring high-Q inductors

A common approach used to measure an inductor is to connect it in a tuned circuit with a known value of capacitance. In conjunction with an RF signal generator and other measurement instruments, the Q factor and inductance are then readily obtainable.

Unfortunately, loading effects of the test equipment can compromise measurement accuracy but this can be improved by adding a simple diode detector circuit.

The diode detector monitors the RF voltage (V_{NULL}) at the input to the series tuned circuit (L1 & C1). The signal generator is then tuned for a minimum RF voltage at this node, as measured at the detector output (V_{DET}) with a high-impedance DVM. With a high-Q inductor the detector output voltage at null



may be 100μV or less.

The series resistance of the tuned circuit is given by:

$$r = R2 \times V_{NULL}/V_{IN}$$

when r << R2 and V_{IN} and V_{NULL} are the RF voltages at the input and the detector nodes. Typically, R1 = R2 = 100Ω so that at resonance the signal generator sees a 50Ω load.

At resonance, the detector impedance has little effect as it is shunted by the low series resistance of the tuned circuit. Almost any high-speed diode can be used provided that its load resistance is sufficiently high. However, diodes with lower equivalent shunt resistances at zero bias (eg, Schottky and germanium) will work better with lower load resistances.

A high input impedance DVM such as the HP/Agilent 34401A must be used to minimise loading. Also, care has to be taken to ensure that "spillback" from the DVM isn't rectified by the diode detector, falsifying the reading. An RC filter can be used to significantly reduce the effects of noise injected by a DVM. Alternatively, an analog meter may be preferable as it produces very little noise.

Bruce Griffiths.
Hamilton, NZ. ($35)

Stage microphone muting circuit

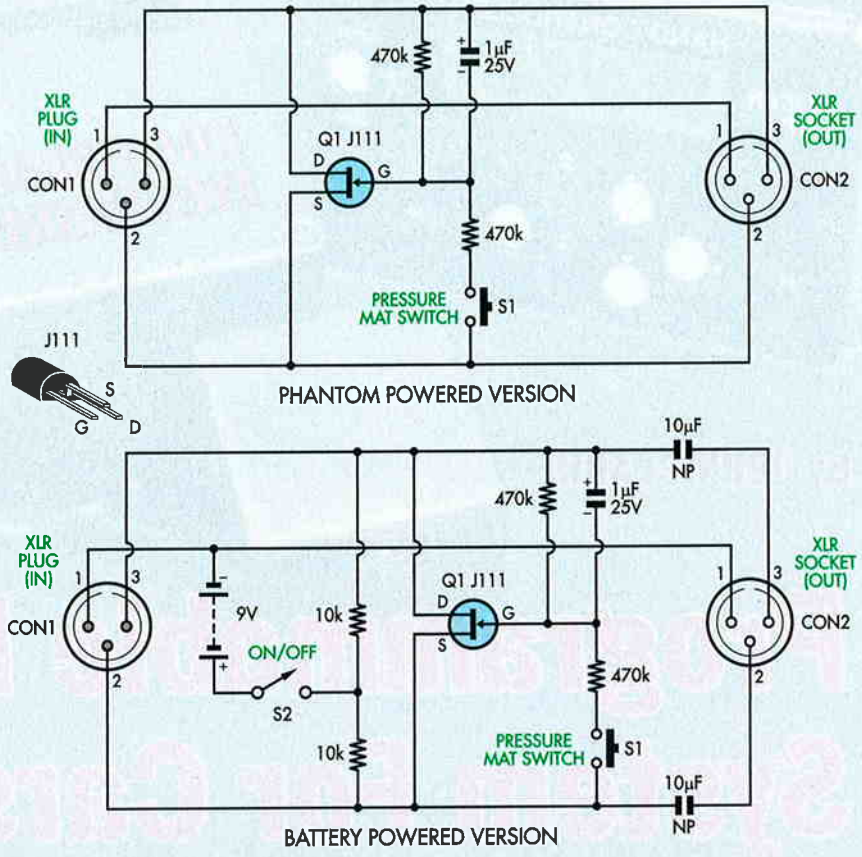
This simple pair of circuits addresses the problem of open microphones, which commonly pick up extraneous sounds and limit the gain of live sound systems before feedback. The circuits are designed so that their microphones are active only when the vocalists are standing on pressure mats.

One version of the circuit is for mixers that supply phantom microphone power. Operation is very straightforward; JFET Q1 is used to short-circuit the balanced audio output from the microphone whenever the pressure mat switch is open.

When the vocalist steps on the pressure mat, the switch closes and the gate voltage of Q1 goes negative with respect to its source. This causes the drain-source resistance to swing very high, removing the short circuit from the signal lines. The 470kΩ resistor and 1µF capacitor provide a gentle turn-on and turn-off characteristic (about two seconds) in order to reduce clicks and pops.

A second version can be built for mixers that do not have a phantom supply. It adds a battery supply for biasing the JFET as well as DC blocking capacitors in series with the output lines. Note that while other JFETs can be substituted for the J111, be sure that their drain-source resistance is less than 100Ω to provide useful off-state attenuation.

Robert Budniak, via email. ($40)



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By JOHN CLARKE

Programmable Ignition System For Cars; Pt.2

Six Versions To Build To Suit Your Car's Trigger Input!

This month, we describe the circuit for the LCD Hand Controller module and provide all the assembly details for the Programmable Ignition. There are six versions to build.

LAST MONTH, we published the circuit details for the Programmable Ignition Timing Module and its companion Ignition Coil Driver Module and described their operation in some detail. The various input trigger circuits (points, reluctor, Hall sensor, optical, etc) were also described.

LCD Hand Controller

That just leaves the LCD Hand Controller Module. Its circuit is shown in Fig.7. It comprises an LCD module, a 4017 decade counter (IC1), a DB25 socket and several pushbutton switches. This unit connects to the main circuit via a standard DB25 RS-232 cable.

Signals from the microcontroller in the Programmable Ignition Timing Module drive both the LCD module and IC1. IC1 has 10 outputs and each output independently goes high in sequence as it is clocked at its pin 14 input. A high at the reset (MR, pin 15) sets the "0" output at pin 3 high.

Each output connects to a switch. When a switch is closed, it pulls pin 9 of the DB25 socket high whenever its corresponding output on IC1 is high. This allows the microcontroller (in the Ignition Timing Module) to recognise which switch is closed.

The LCD is driven using data lines DB7-DB4. The display readings are entered via the data lines and are controlled via the EN and RS (Enable and Register Select) inputs.

Note that the data lines and the EN & RS lines are all connected to ground via 330Ω resistors. These resistors allow the LCD module to be driven without the signals being corrupted by interference from the car's ignition.

Finally, trimpot VR1 is used to adjust the display contrast.

Construction

OK, that completes the circuit description. Let's now build all the modules for the unit.

As shown in the accompanying diagrams, the Programmable Ignition system is built on three PC boards – one for the Programmable Ignition Timing Module (code 05104071, 103 x 82mm); one for the Ignition Coil Driver Module (code 05104072, 40 x 39mm); and one for the LCD Hand Controller (code 05104073, 115 x 65mm). The Programmable Ignition Timing Module board is housed in a diecast aluminium case measuring 119 x 93 x 57mm, while the Ignition Coil Driver board goes into a much smaller diecast

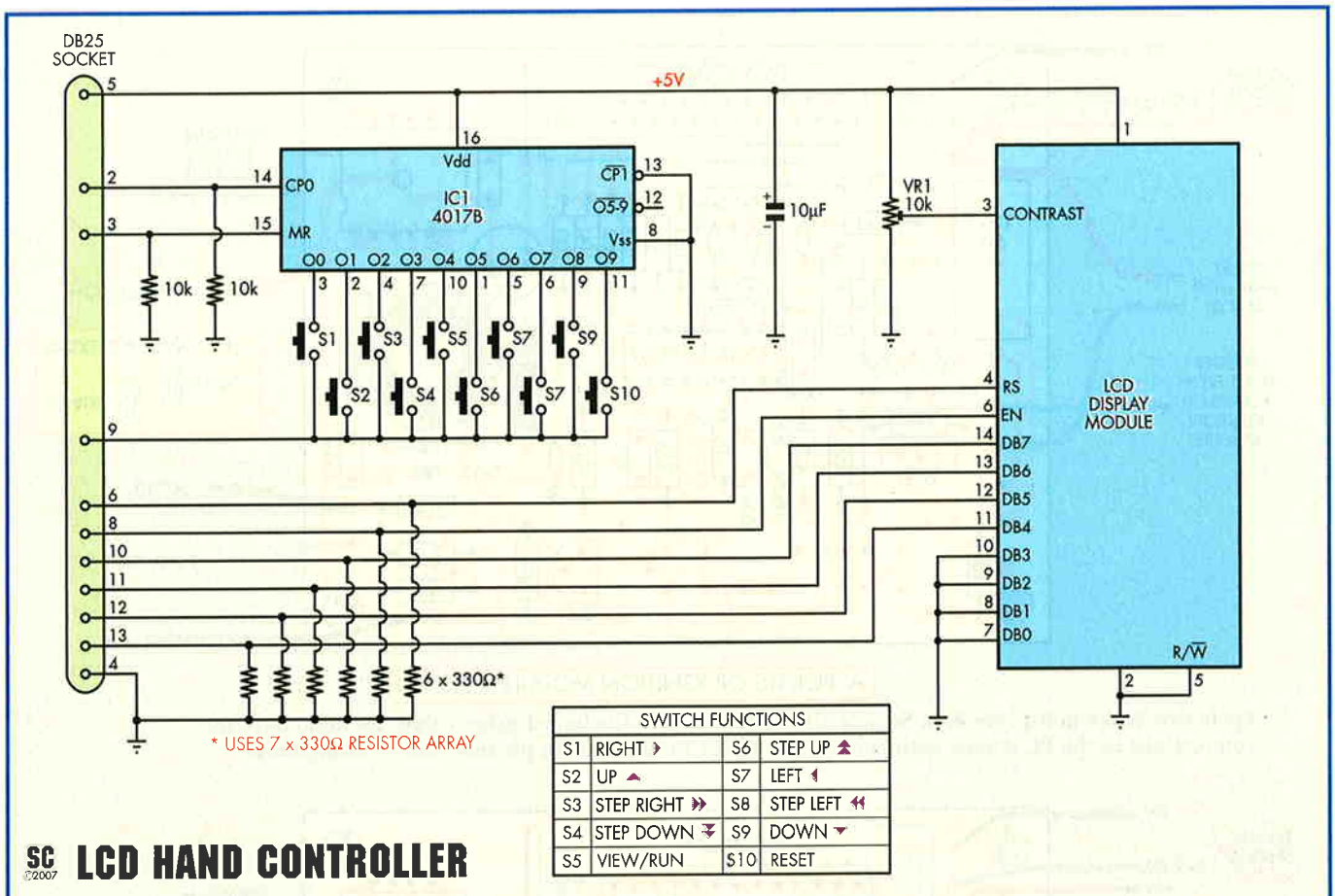


Fig.7: the circuit for the LCD Hand Controller is quite simple. It uses 10 switches, an LCD module, a 4017 counter (IC1), a DB25 socket, a 10µF capacitor and a few resistors. Trimpot VR1 sets the display contrast.

case measuring 51 x 51 x 32mm.

The LCD Hand Controller board goes into a 120 x 70 x 30mm plastic case with a clear lid.

Before installing any parts, check each PC board for etching defects by comparing it against a printout of its pattern (you can download the relevant board files from the SILICON CHIP website). Check also that all the holes have been drilled and that the hole sizes for the larger parts are correct.

Ignition timing module

There are six different component layouts for this board, one for each different trigger input. It's just a matter of choosing the one that's applicable to your car.

For example, if your car has a reluctor distributor, follow the reluctor version overlay diagram – see Fig.10. Similarly, if it has a Hall effect or Lumenition pickup module, use the layout of Fig.11, etc.

It's not difficult to recognise the different sensor types. Reluctor distributors have a coil and a magnetic ring that has as many points (or protrusions) as the number of engine cylinders. By contrast, Hall effect distributors include a metal vane that passes through a gap in the Hall sensor itself. Lumenition triggers are similar to Hall effect sensors and so the overlay diagrams for these trigger types are the same – see Fig.9.

Start construction by installing PC stakes at the external wiring points, then solder in all the wire links. That done, install the resistors, using Table 1 as a guide to select the values. In addition, it's also a good idea to check each resistor using a digital multimeter (DMM) to make sure you have the correct resistor for each position.

Next, install the IC socket for the microcontroller, making sure that it's oriented with its notch at the lefthand end, as shown. Don't install the microcontroller (IC1) at this stage though – that step comes later.

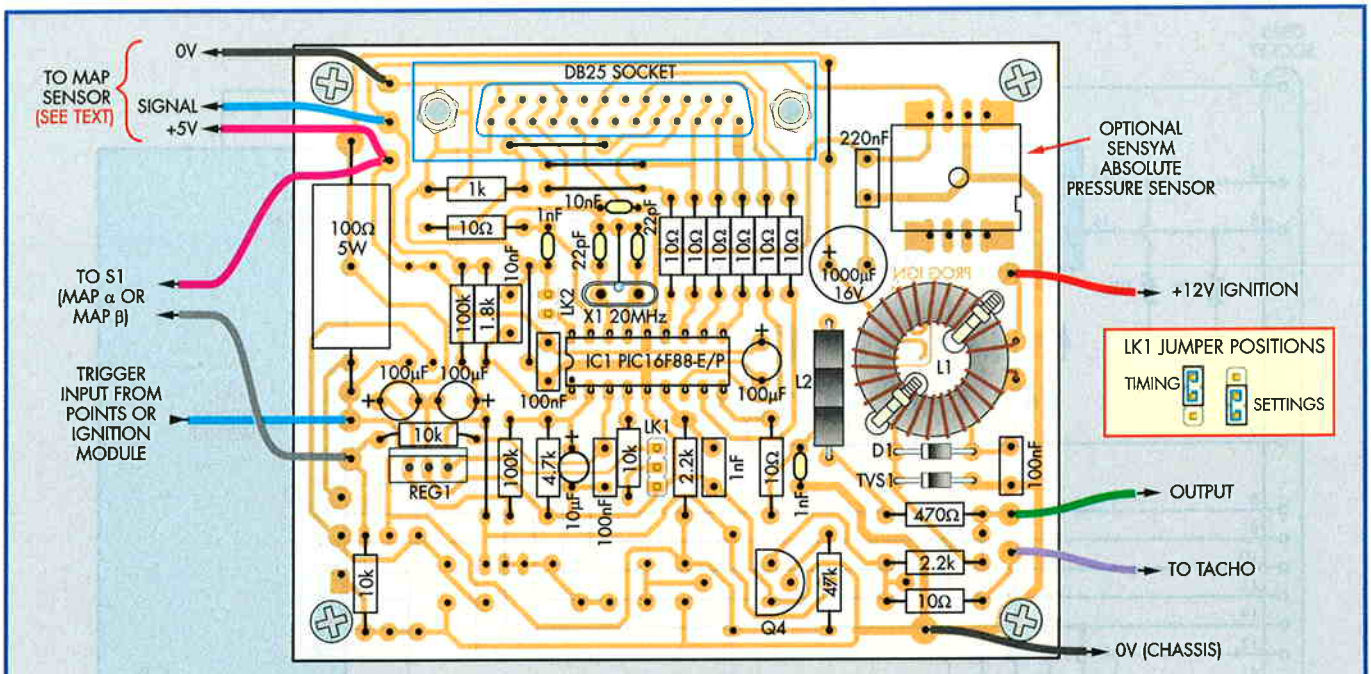
Diode D1 and TVS1 are next on the list. Note that D1 must be oriented as shown, while TVS1 can be installed either way around. Follow these with the transistor(s) and REG1, taking care to ensure that these parts are oriented correctly.

Trimpot VR1 should now be installed if you are building the reluctor version (Fig.10). It should be oriented with its adjusting screw to the left.

The link headers for LK1 and LK2 can be installed now. LK1 is a 3-way header while LK2 is a 2-way header. Place a jumper shunt over two of the three pins for LK1 and another jumper shunt onto both pins for LK2.

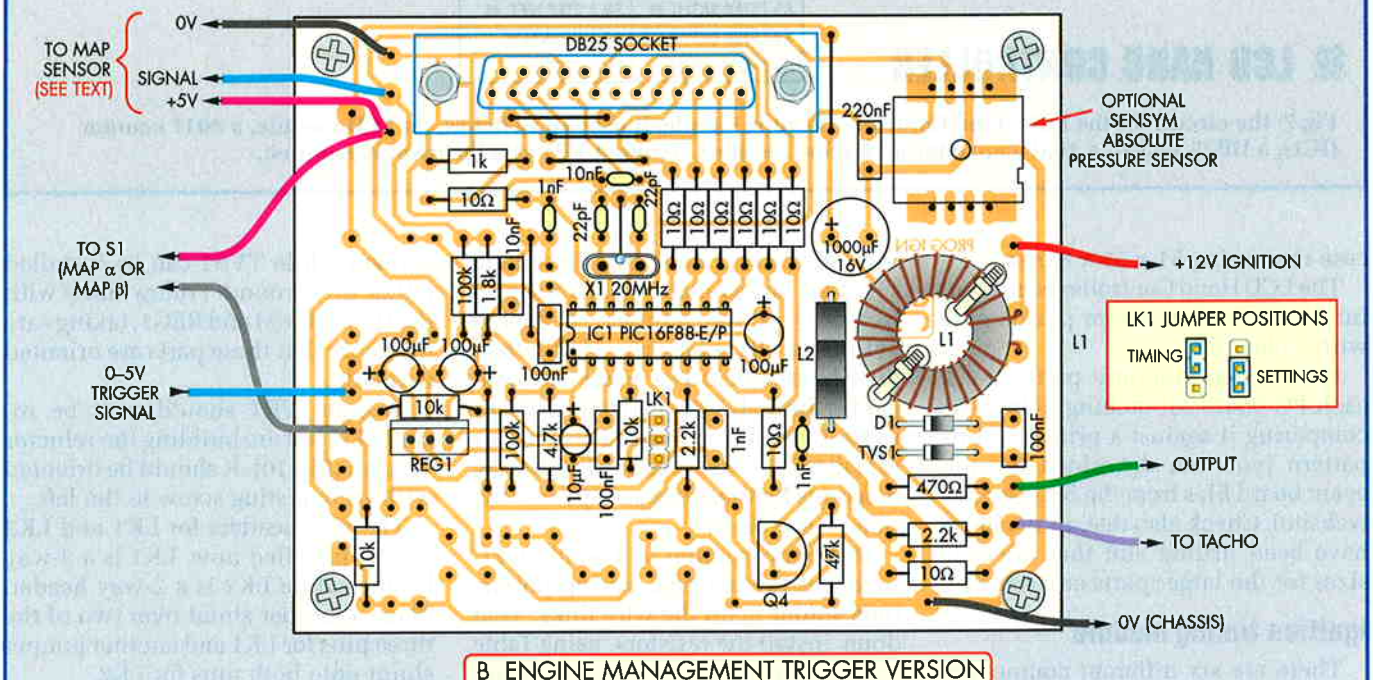
Now for the capacitors. Several types are used on the board: ceramic, MKT and electrolytic. **The ceramic capacitors are all shown on the overlays in yellow, so that you don't get them confused with the MKT types.** Be sure to orient each electrolytic capacitor with the polarity shown.

Once the capacitors are all in, install the crystal (X1). Note that the crystal's metal case is earthed using a short wire link. This link is soldered



A POINTS OR IGNITION MODULE VERSION

Fig.8: this is the points version. Secure all wiring leads to the board using cable ties and cover the connections to the PC stakes with heatshrink tubing or silicone, to prevent them coming loose.



B ENGINE MANAGEMENT TRIGGER VERSION

Fig.9: the engine management trigger version requires no additional input conditioning circuitry. In this case, the ECU trigger signal goes straight to pin 6 of IC1 via a 2.2kΩ resistor.

to the case and runs to a pad on the PC board between the two 22pF ceramic capacitors.

Sensym pressure sensor

If you are using the Sensym absolute pressure sensor (eg, if you car doesn't already have a MAP sensor or you are not using a seconhand MAP sensor), then this can be installed now. Note the orientation notch on the sensor – this goes towards the righthand edge of the PC board. If you get the Sensym sensor's orientation wrong, it will not be powered but no damage will result from doing this.

Inductors

Inductors L1 & L2 are next on the list. First, L2 is made by passing a 0.7mm tinned copper wire link

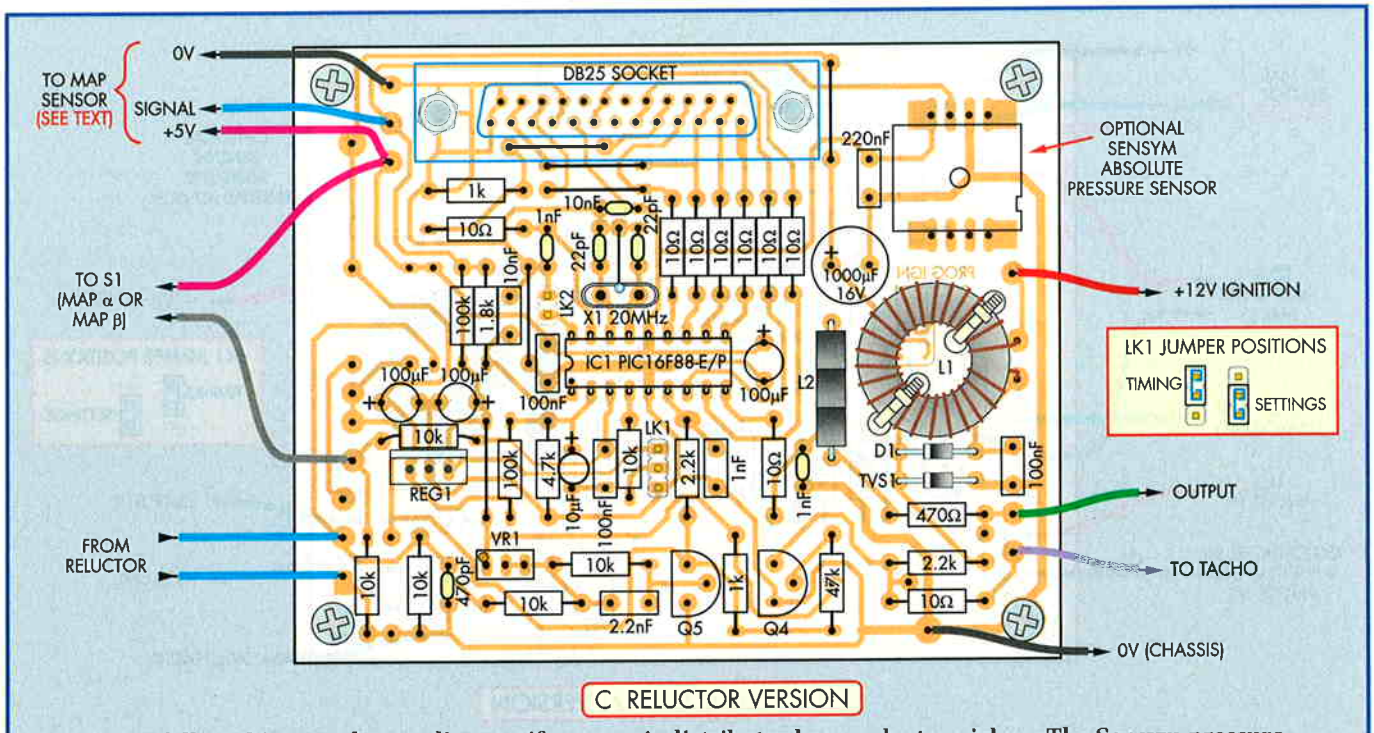


Fig.10: follow this parts layout diagram if your car's distributor has a reluctor pickup. The Sensym pressure sensor is used only if there is no external MAP sensor (applies to all versions).

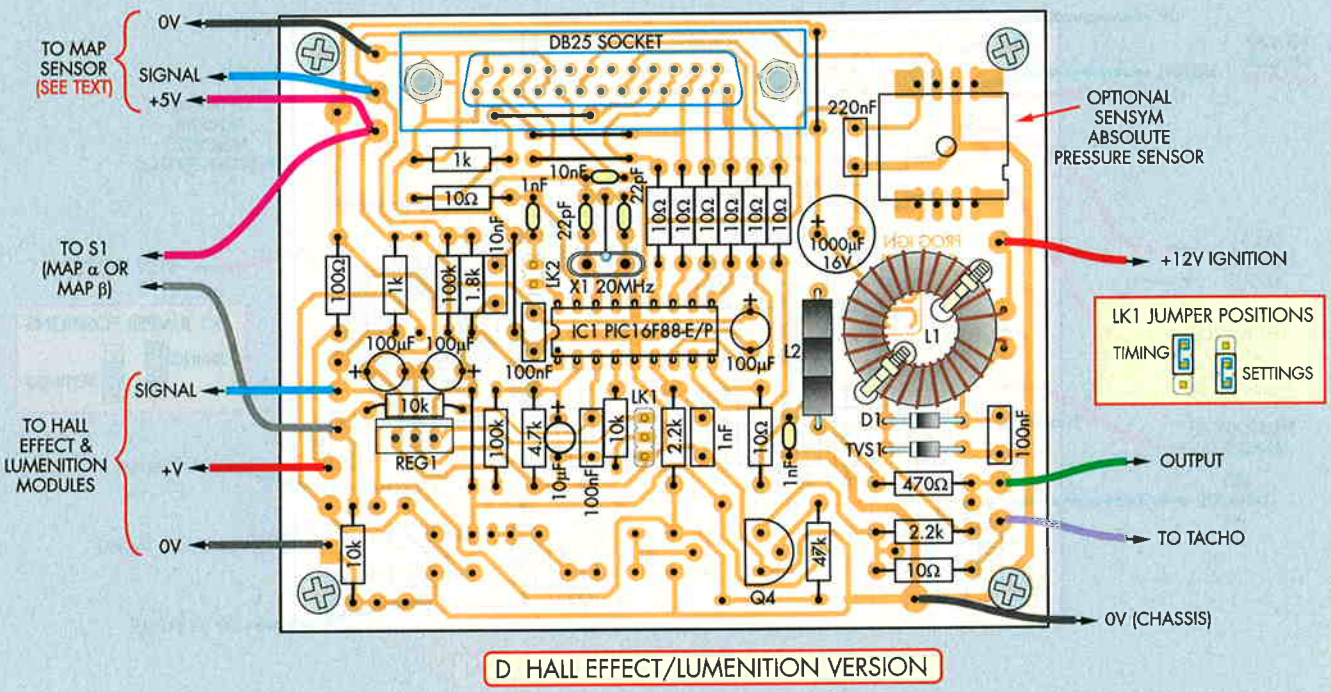
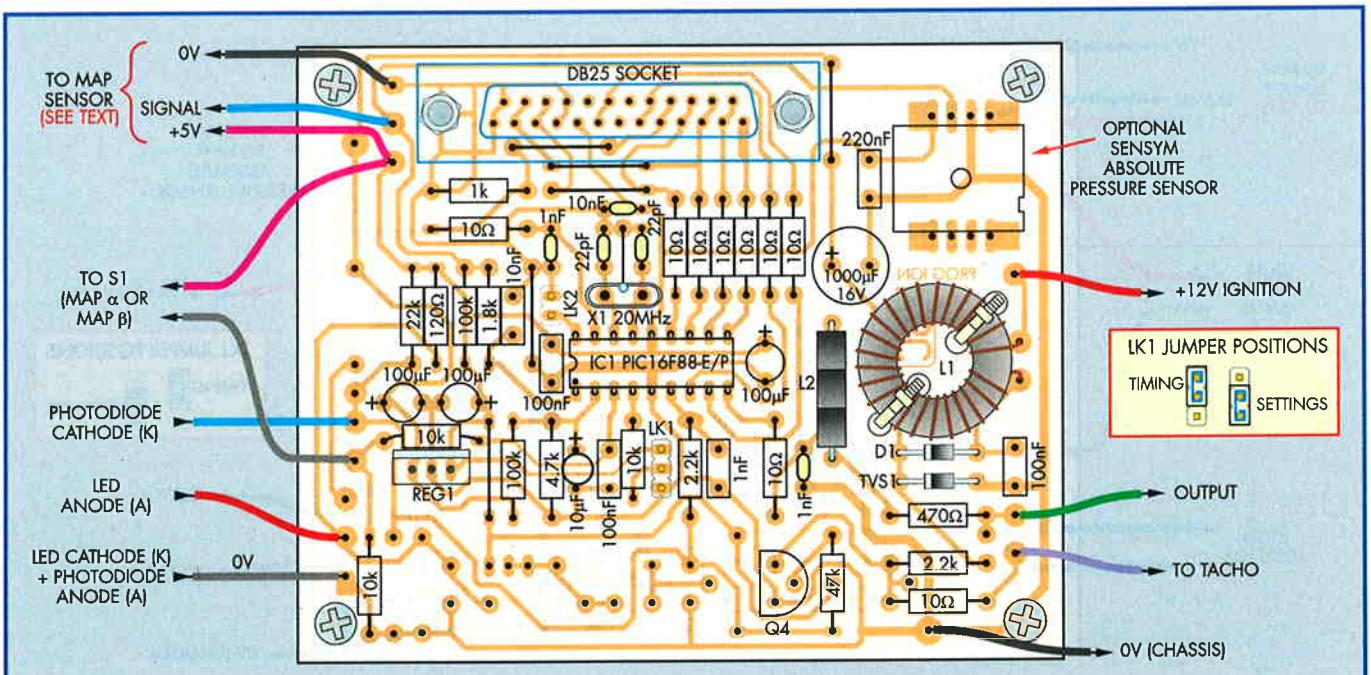


Fig.11: this is the layout to follow if the distributor uses a Hall Effect device or a Lumenition module. Take care with component orientation during assembly.

through three ferrite beads. A length of the 4mm heatshrink tubing is then slid over the three cores and shrunk down to hold everything in place, after which the assembly can be soldered to the board.

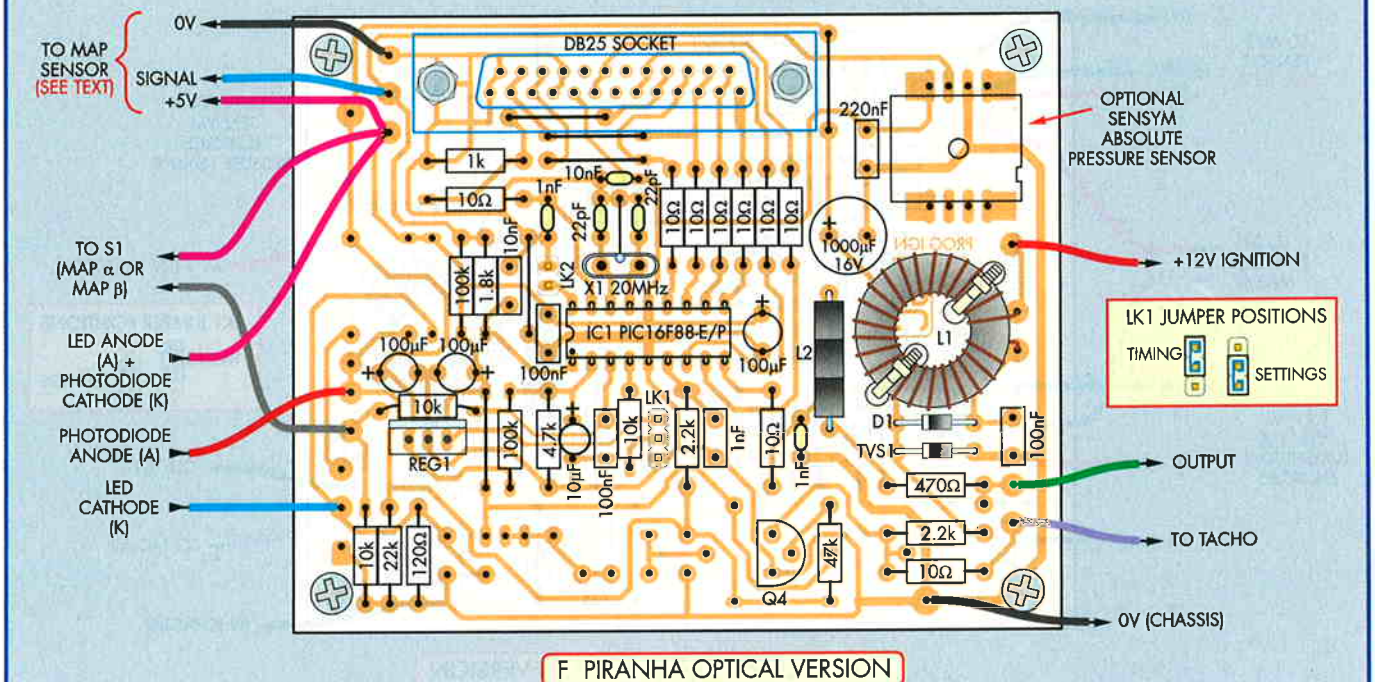
Inductor L1 is much larger. It's made by winding 23 turns of 0.5mm enamelled copper wire through a 15 x 8 x 6.5mm powdered-iron toroidal core. **These turns should be evenly spaced around the core, as shown on the overlays.** That done, the wire ends are stripped of insulation and soldered to the PC pads. The toroid is then secured to t he board using two plastic cable ties.

Finally, the DB25 socket can be installed in position. Before doing this though, two D-connector nut extenders must to be attached to the



E CRANE OPTICAL VERSION

Fig.12: build this version if your distributor has been fitted with a Crane optical pickup. Make sure that inductor L1 is firmly secured, to ensure reliability (all versions).



F PIRANHA OPTICAL VERSION

Fig.13: the Piranha optical pickup version is almost identical to the Crane version but note the different locations for the 22kΩ and 120Ω resistors.

PC board. These are simply passed through their two mounting holes and secured using spring washers and nuts on the underside of the board. **In addition, the righthand extender is fitted with a Nylon washer to prevent the spring washer and nut from shorting to nearby tracks. Don't leave this washer out!**

By contrast, the lefthand extender makes contact with the ground track on the PC board, so that the shell of the socket is earthed when it is installed. That way, when the DB25 lead is connected, its shield will also be earthed.

The DB25 socket can now be secured in place using a second set of nut extenders and its pins soldered to the PC pads. Note that you may need to cut down the extender threads so

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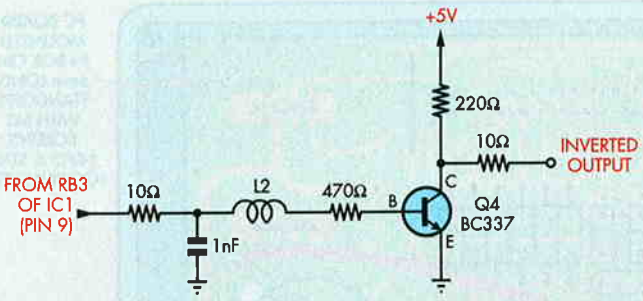


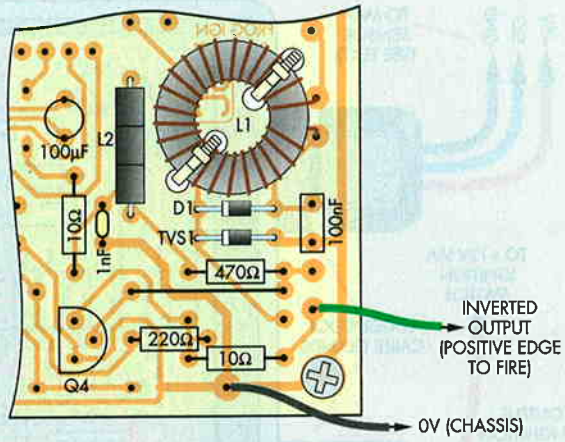


Fig.14: these diagrams show the modifications required to invert the output from the Ignition Timing Module.

the nuts sit flush with the socket's mounting flange.

Inverting the output

In normal operation, the RB3 output from the Programmable Ignition Timer Module goes high in order to turn on transistor Q1 (via Q3 & Q2) in the Ignition Coil Driver. This in turn allows current to flow through the primary of the coil.

Conversely, when RB3 goes low, Q1 switches off, the current through the coil is interrupted and the coil "fires" the relevant spark plug. So a low-going signal at the Ignition Timing Module's output normally causes the Ignition Coil Driver to fire a plug via the coil.

However, there may be some applications where the output from the Programmable Ignition Timing Module needs to be inverted; ie, so that a low output "charges" the coil and a high-going output causes the plug to fire. This may be the case if you connect the Programmable Ignition Timing Module to a different ignition coil driver.

In this case, an inverted output can be provided using the tachometer driver transistor (Q4). The necessary changes to the circuit and to the PC board layout are shown in Fig.14. The only extra parts required are a 220Ω resistor and some tinned copper wire for the link.

Housing

Having completed the board assembly, the next step is to install it in its metal diecast case. Fig.15 shows the assembly details.

The first step is to position the board inside the case and mark out its four mounting holes. That done, remove the PC board and drill the mounting holes to 3mm. Deburr each hole using an oversize drill bit, then secure a 6mm-long tapped spacer to each mounting point using an M3 x 15mm screw inserted from the outside of the case.

You will also have to drill a hole in one end of the box to accept a cable gland for the various external leads (ie, +12V lead, trigger signal leads and signal output lead). An additional hole for a second cable gland will also be required if you are using an external MAP sensor (see Fig.15).

Next, a 3mm hole must be drilled through the side of the box adjacent to the GND (0V) PC stake. This mounting hole is used to terminate an earth wire from the PC board via a crimped eyelet connector. A second wire terminated in an eyelet connector is also

Table 2: Capacitor Codes

Value	µF code	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
10nF	.01µF	10n	103
2.2nF	.0022µF	2n2	222
1nF	.001µF	1n0	102
470pF	NA	470p	471
22pF	NA	22p	22

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	3	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	7	10kΩ	brown black orange brown	brown black black red brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	1	1.8kΩ	brown grey red brown	brown grey black brown brown
❑	1	1.2kΩ	brown red red brown	brown red black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	9	10Ω	brown black black brown	brown black black gold brown

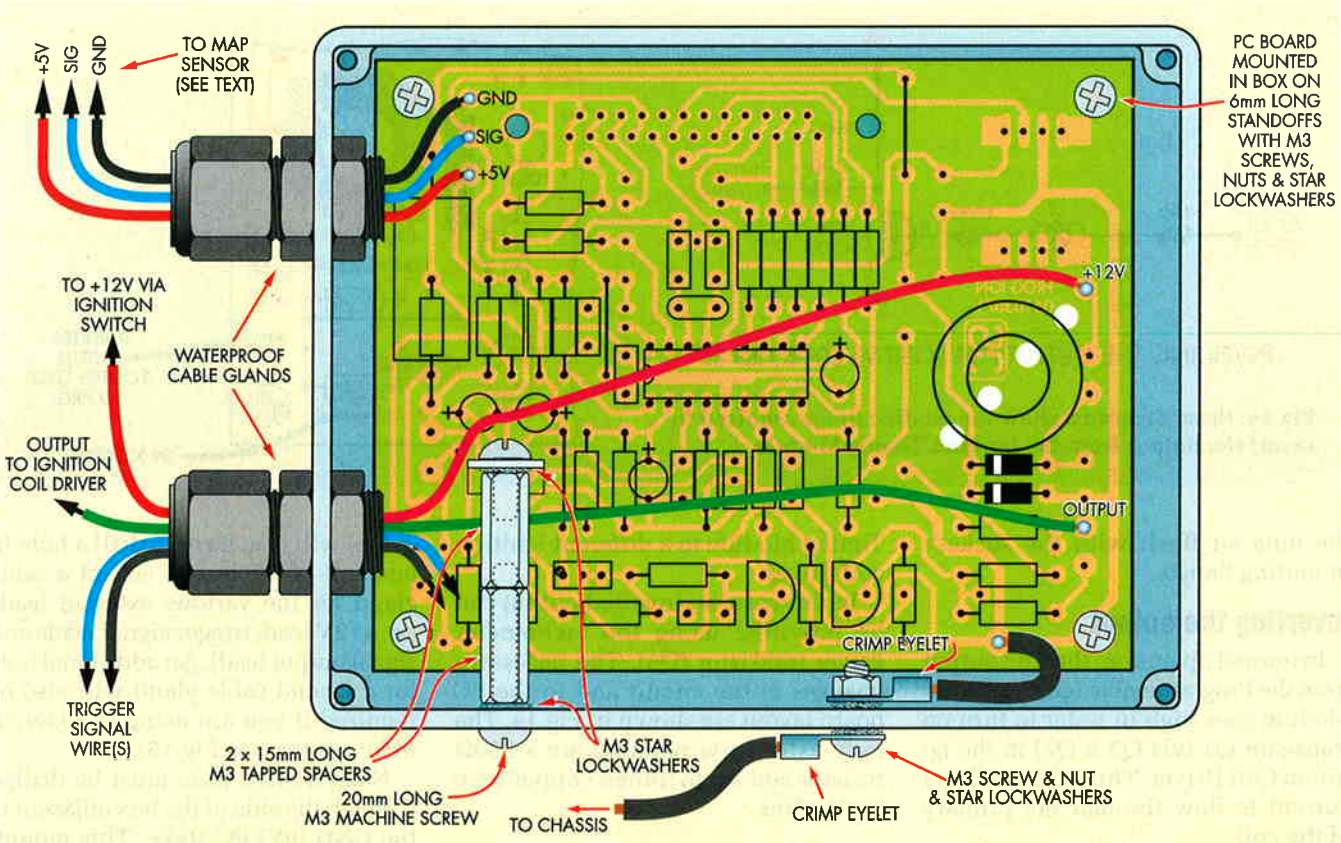
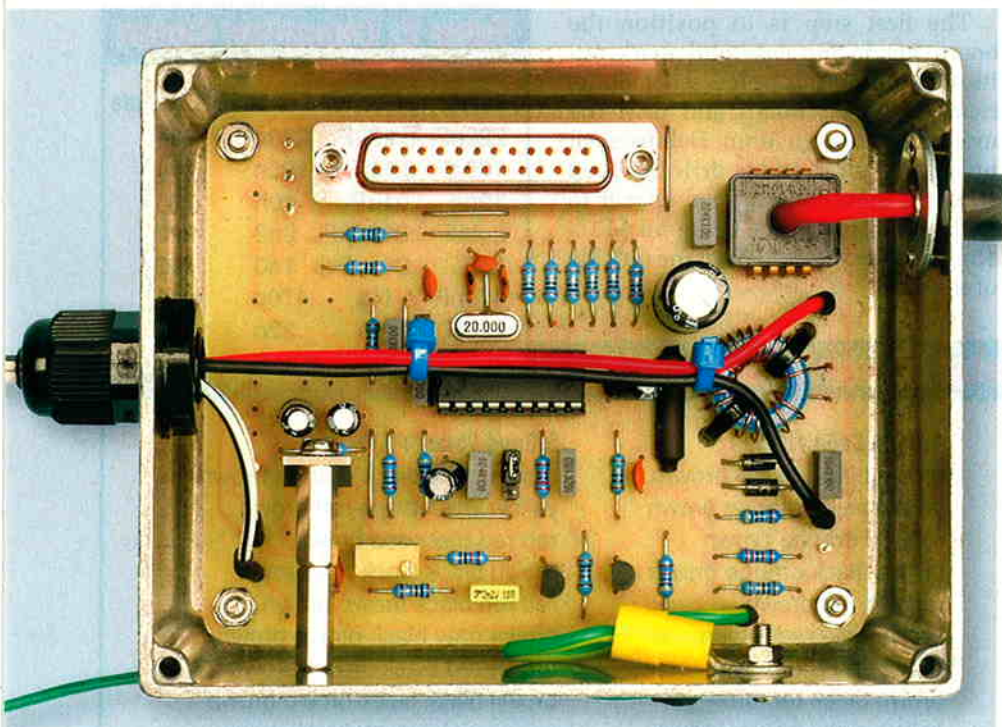


Fig.15: this diagram shows the final assembly and external wiring details for the Ignition Timing Module. Note how the 0V (ground) rail on the PC board is connected to one side of the case, with a lead then run from this point to the vehicle's chassis. Use cable ties to help secure the leads, both inside and outside the case.



This view shows the assembled PC board for the Ignition Timing Module with the optional internal Sensym MAP sensor fitted (ie, when there is no existing external MAP sensor or you are not using a secondhand MAP sensor). Make sure that the unit is ruggedly built (ie, so that no leads can come adrift).

attached to the outside of the case to make the chassis connection, with the entire assembly secured using a M3 x 9mm screw, nut and star washer – see Fig.15.

Another 3mm hole is drilled to allow the metal tab of regulator REG1 to be secured to the case using two M3 x 15mm tapped metal spacers. This arrangement serves a dual purpose: (1) it mechanically secures the regulator to prevent its from breaking; and (2) it provides heatsinking for the regulator tab.

The two spacers are secured to REG1's tab using an M3 x 20mm screw, while an M3 x 9mm screw secured the spacers to the side of the case.

Note that star washers must be used under each screw head, to prevent the assembly from shaking loose.

Hose adapter

If you are using the on-board Sensym pressure sensor, then a hose connection will be required from the sensor to a chassis-mount flange (or through-piece) on the side of the box. This piece serves as both an anchor

Manifold Pressure Sensor Options

IN ORDER TO utilise the vacuum advance feature provided by the Programmable Ignition System, some means of monitoring manifold pressure is required.

There are several options available here. The simplest option is to use the MAP (manifold air pressure) sensor that's already installed on your car (if it has one). This sensor would normally be used to detect manifold pressure for the car's own Engine Management Unit, to control the timing.

If your car does not have a MAP sensor, then you can easily obtain one to do the job. There are different sensors to suit normally aspirated engines and to suit turbocharged engines.

Normally aspirated engines do not boost the air pressure for the fuel mixture and so a 1-bar (one atmosphere, 100kPa or 15psi) sensor is all that is required. These sensors measure the air pressure compared to a vacuum and output a voltage close to 4V for atmospheric pressures and close to 0V for a vacuum.

Turbo engines boost the air pressure above atmospheric and consequently a 1-bar sensor is inadequate. This is because the output from a 1-bar sensor would not change for pressures above 1-bar. There is also a possibility that the sensor could be damaged if the pressure went too far beyond its rating.

In this case, a 2-bar sensor should be adequate for most applications. However, if the boost is greater than 2-bar, a 3-bar sensor will be required instead.

One option is to use an on-board Sensym sensor that covers from 0-1 bar or from 0-2 bar, as specified in the parts list. This device is best used at temperatures ranging from 0-85°C and so the Programmable Ignition Timing Module should be mounted inside the cabin rather than in the engine bay.

Alternatively, most automotive wreckers can sell you a MAP sensor quite cheaply. These are available from various models of Holden, Honda, Toyota, Subaru and others. Details of the Holden type 1-bar, 2-bar and 3-bar MAP sensors and the Motorola 2.5-bar MAP sensor are available at this web site: http://www.pgmfi.org/twiki/bin/view/Library/MapSensor

Typically, the 1-bar Holden sensors are designated with a 039, 460 or 883 code. 2-bar sensors have a 886, 012, 539 or 609 code and 3-bar sensors have a 749 code. The A, B and C labels refer to the positioning of the Ground, Signal and +5V terminals.

point and as a 3mm-to-5mm adapter.

This is necessary because the sensor's hose connection is 3mm in diameter while a standard automotive vacuum tube requires (at least) a 5mm fitting to enable it to stay in place without air leaks.

A 15mm round brass spacer is used as the adapter. The 3mm-diameter hose from the sensor is pushed inside the spacer at one end (ie, the end inside the case), while the external vacuum tube is fitted over the spacer at the other end (outside the case).

Note that it will be necessary to enlarge the hole at one end of the spacer slightly to accept the 3mm (ID) hose. Silicone sealant can be used later, when fitting the hoses, to ensure that the connections are air-tight.

Fig.16 shows how the adapter is fitted. First, a brass nut is soldered to one end of the adapter, after which the adapter is pushed through a 5mm hole in the side of the case. It is then clamped in position using a 20mm OD washer and a couple of M3 x 6mm machine screws that go into tapped holes in the washer (or you could use M2 x 10mm screws and nuts).

Alternatively, you can do away with the adapter altogether and pack the inlet on the Sensym sensor out with several layers of heatshrink tubing so that the 5mm hose is a tight fit. That way, the 5mm (ID) vacuum hose that runs to the engine manifold can simply pass through a hole in the case and

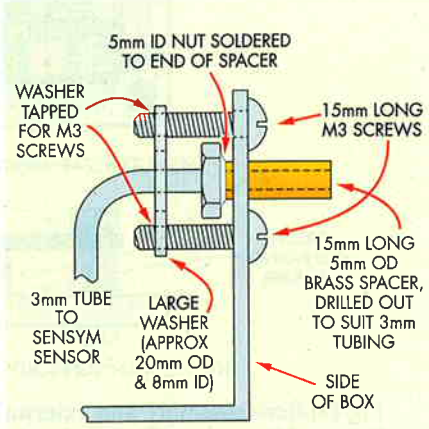

5mm ID NUT SOLDERED TO END OF SPACER
WASHER TAPPED FOR M3 SCREWS
15mm LONG M3 SCREWS
15mm LONG 5mm OD BRASS SPACER, DRILLED OUT TO SUIT 3mm TUBING
3mm TUBE TO SENSYM SENSOR
LARGE WASHER (APPROX 20mm OD & 8mm ID)
SIDE OF BOX

Fig.16: a simple adapter made from a brass spacer can be used to connect the 3mm outlet on the Sensym pressure sensor to a standard 5mm vacuum hose.

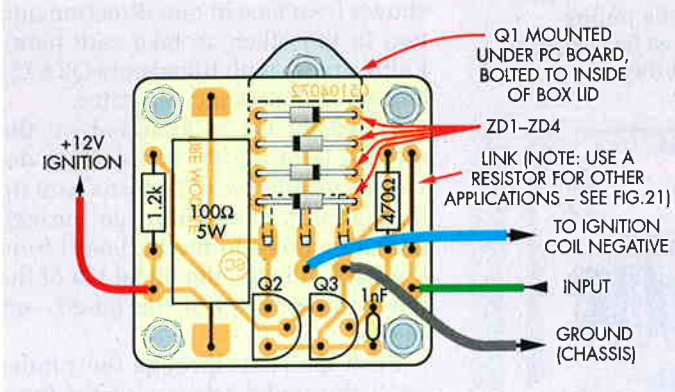
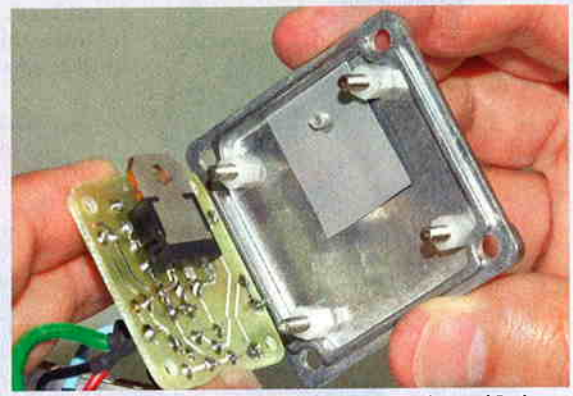


Fig.17: this is the parts layout for the Ignition Trigger Module. Note the different orientations for ZD1-ZD4.



The metal tab of the Darlington transistor (Q1) must be insulated from the case using a TO-218 insulating washer and a Nylon screw and nut.

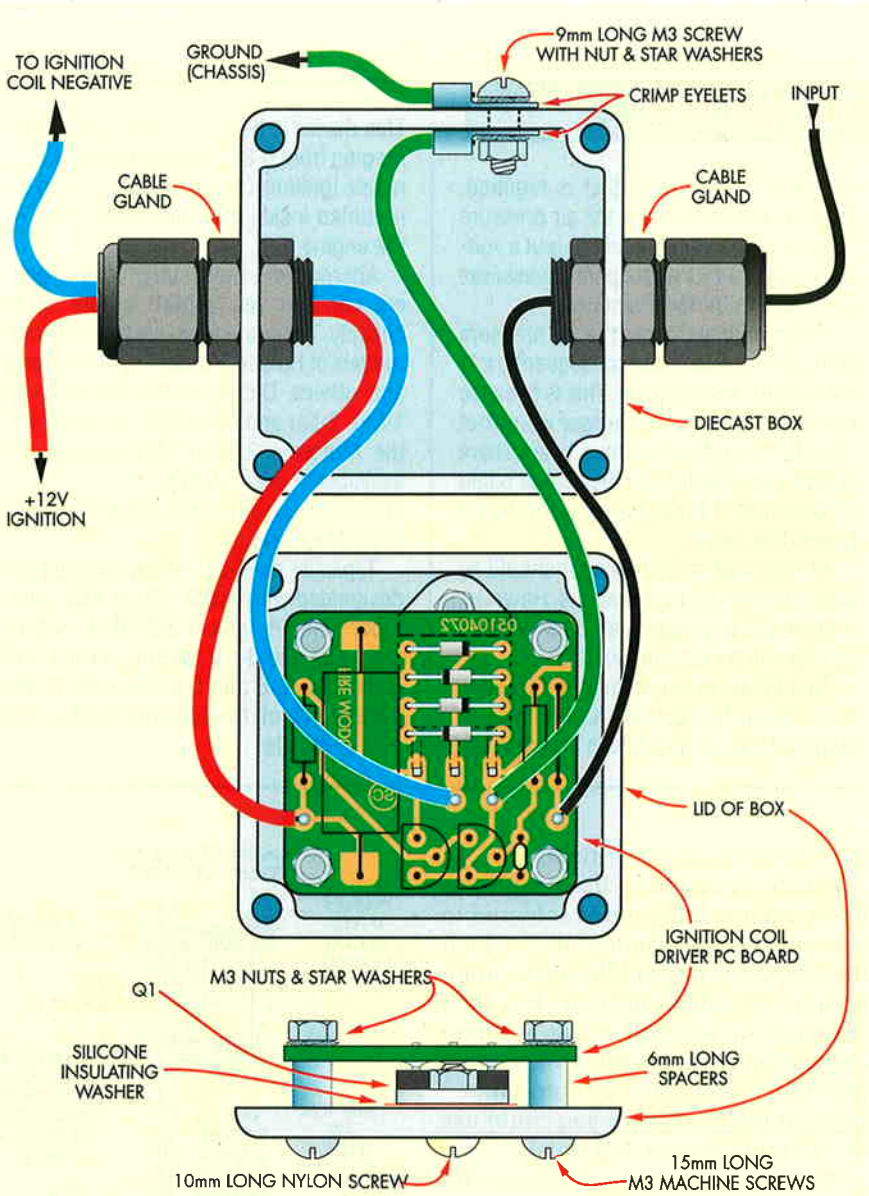
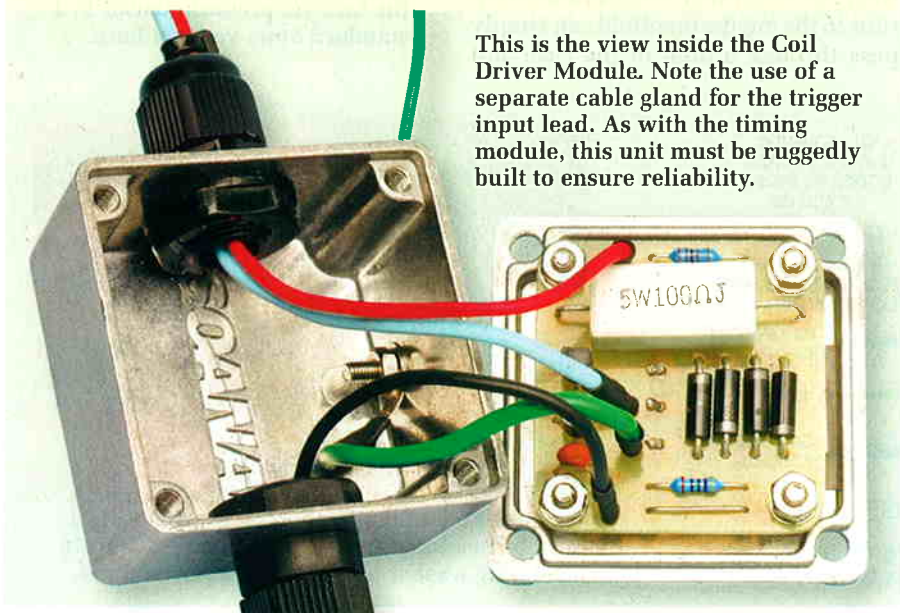


Fig.18: final assembly and external wiring details for the Ignition Coil Driver. After assembly, use a multimeter (set to a low ohms range) to confirm that the metal tab of Darlington transistor Q1 is properly isolated – ie, it must not be shorted to the case.



This is the view inside the Coil Driver Module. Note the use of a separate cable gland for the trigger input lead. As with the timing module, this unit must be ruggedly built to ensure reliability.

go straight to the Sensym pressure sensor.

As before, silicone sealant can be used to ensure an airtight fit but be careful not to block the sensor inlet with the sealant.

Once all the holes have been drilled in the case, the PC board can be fitted and the assembly completed as shown in Fig.15. Be sure to use automotive wiring for all external connections. These leads should all be secured using cable ties and the connections to the PC stakes covered with heatshrink tubing. This is necessary to prevent the leads from vibrating and coming adrift.

Wiring the pressure sensor

There are three options when it comes to wiring the pressure sensor:
(1) If you are using an existing MAP sensor, connect the signal lead only. **DO NOT connect the +5V and 0V supply leads** (the sensor will already have supply connections).
(2) If you are using an external (eg, secondhand) MAP sensor that you've added to the vehicle, then connect all three leads (ie, signal, +5V and 0V).
(3) If you are using the on-board Sensym sensor, do not make any external connections (the second cable gland can be deleted).

Ignition Coil Driver

Fig.17 shows the assembly details for this small PC board.

Begin by installing the wire link, then install the 1.2kΩ and 470Ω resistors. The 100Ω 5W resistor can then go in – it should be mounted all the way down onto the PC board, so that it cannot vibrate and break its leads.

Zener diodes ZD1-ZD4 are next on the list. Be sure to orient them as shown (two face in one direction and two in the other, so take care here). Follow these with transistors Q2 & Q3 and the 1nF ceramic capacitor.

Transistor Q1 is mounted on the underside of the PC board. This device is installed with its leads bent up through 90°, so that they go through matching holes in the PC board from the track side (ie, the metal tab of the device faces away from the board – see photo).

Push the leads through their holes until the metal tab is exactly 6mm below the underside of the PC board, then lightly solder one of the leads. This will allow you to make any adjust-

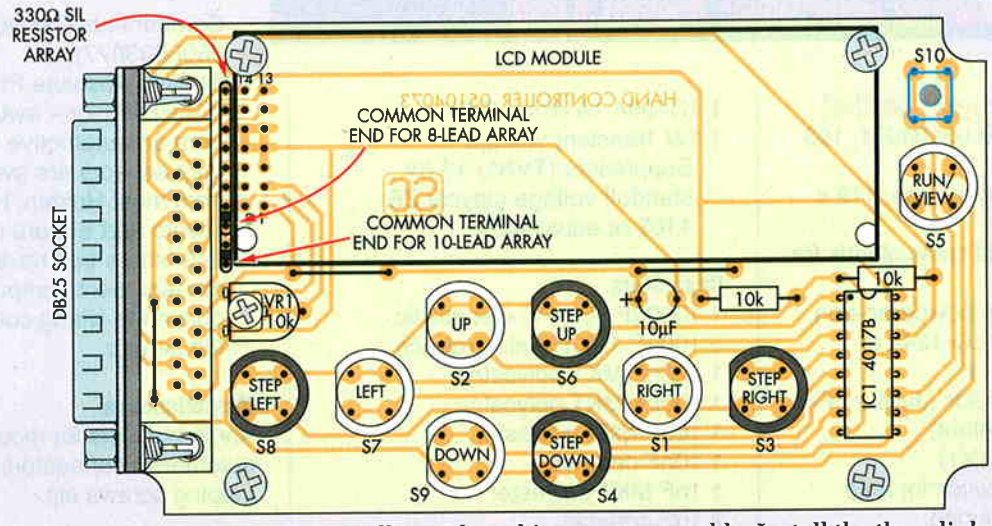


Fig.19: the LCD Hand Controller PC board is easy to assemble. Install the three links first and note that the switches, IC and 10µF electrolytic capacitor are polarised. The LCD is connected via a 14-way DIL pin header.

The PC board mounts inside the case on four M3 x 12mm spacers and is secured using M3 screws, nuts and flat washers – see Fig.19. Note how the 10µF capacitor is mounted on its side, so that it clears the front panel.

ments as necessary before completing the soldering.

Finally, complete the board assembly by installing PC stakes at the four external wiring points.

Once completed, the Ignition Coil Driver PC board can be installed in its diecast case – see Fig.18. As shown, the board in mounted on the lid of the case on 6mm tapped spacers and secured using M3 x 15mm screws, nuts and star washers. Transistor Q1 (on the underside of the board) is fastened to the lid for heatsinking.

The first step is to mark out all the mounting holes on the lid. Drill these holes to 3mm, then carefully deburr them using an oversize drill. In particular, make sure that Q1's mounting hole is perfectly smooth and free of any metal swarf that could puncture its insulating washer.

Note too that Q1's mounting hole should be chamfered (use an oversize drill bit). This is necessary to avoid sharp edges around the circumference of the hole, to prevent arcing through the insulating washer (due to the high voltages present on the transistor tab).

Once the holes have been "cleaned up", fit the four tapped spacers to the board mounting positions and secure them using the M3 x 15mm screws. That done, install transistor Q1's Nylon mounting screw and insulating washer (see photo), then slip the board into position and secure it using M3 nuts and star washers.

Don't leave the star washers out – they are necessary to ensure that the nuts don't shake loose due to vibration.

Transistor Q1 can now be secured by installing its nut and tightening the Nylon screw (use a pair of needle-nose pliers to hold the nut in position while you "start" the screw). **Finally, use your multimeter (set to a low ohms range) to confirm that Q1's metal tab is indeed electrically isolated from**

Programmable Ignition: Parts List

Programmable Ignition Unit

1 PC board, code 05104071, 103 x 82mm
1 diecast aluminium case, 119 x 93 x 57mm
2 IP68 waterproof cable glands for 4-8mm cable
1 15 x 8 x 6.5mm powdered-iron toroid (Jaycar LO-1242 or equivalent) (L1)
3 5mm Ferrite beads (Jaycar LF-1250 or equivalent)
1 20MHz crystal (X1)
1 SPDT toggle switch for map switching (optional)
1 18-pin DIL IC socket
1 DB25 female straight pin PC mount socket
4 D-connector nut extenders and two locking nuts and shake proof washers
1 2-way pin header
1 3-way pin header
2 jumper pin shorting links
2 crimp eyelets
4 6mm tapped Nylon standoffs
1 3mm Nylon washer
2 M3 tapped x 15mm brass standoffs
1 M3 x 20mm screw
4 M3 x 15mm screws
2 M3 x 9mm screws
8 M3 star washers
5 M3 nuts
10 PC stakes
1 60mm length of 4mm ID heatshrink tubing
2 100mm cable ties
1 2m length red automotive wire
1 2m length black automotive wire
1 2m length green automotive wire
1 2m length brown automotive wire
1 2m length yellow automotive wire
1 150mm length of 0.7mm tinned copper wire
1 600mm length of 0.5mm enamelled copper wire

Semiconductors

1 PIC16F88-E/P microcontroller programmed with ignprgm.hex (IC1)
1 LM2940CT-5 low-dropout 5V regulator (REG1)
1 BC337 NPN transistor (Q4)
1 1N4004 1A diode (D1)
1 1W Transient Voltage Suppressor (TVS1) 13.6V standoff voltage (Jaycar ZR 1162 or equivalent)

Capacitors

1 1000µF 16V PC electrolytic
3 100µF 16V PC electrolytics
1 220nF MKT polyester
1 100nF MKT polyester
1 10nF MKT polyester
1 10nF ceramic
1 1nF MKT polyester
2 1nF ceramic
2 22pF ceramic

Resistors (0.25W 1 %)

2 100kΩ	1 1.8kΩ
2 47kΩ	1 1kΩ
3 10kΩ	1 470Ω
2 2.2kΩ	9 10Ω

Points and ignition module version

1 100Ω 5W resistor

Reluctor version

1 BC337 NPN transistor (Q5)
1 2.2nF MKT polyester capacitor
1 470pF ceramic capacitor
1 100kΩ top-adjust multi-turn trimpot (VR1)
1 47kΩ 0.25W 1 % resistor
2 10kΩ 0.25W 1 % resistors
1 1kΩ 0.25W 1 % resistor
1 PC stake

Hall effect version

1 1kΩ 0.25W 1 % resistor
1 100Ω 0.25W 1 % resistor
2 PC stakes

Optical pickup version

1 22kΩ 0.25W 1 % resistor
1 120Ω 0.25W 1 % resistor
2 PC stakes

Manifold pressure sensor alternatives (see text)

1 ASDX015A24R Sensym (0-15PSI, 0-1bar) Absolute Pressure Transducer (RS Components Cat No. 2508593055) (Farnell Cat. No. 419-7586); or
1 ASDX030A24R Sensym (0-30PSI, 0-2bar) Absolute Pressure Transducer (RS Components Cat No. 2508593077); or
1 Manifold Absolute Pressure (MAP) sensor – available from an automotive wreckers. Map sensors are available from most Holden, Honda, Toyota and Subaru models and others that have an engine management computer. Try to obtain the wiring connector with the sensor.

Miscellaneous

Angle brackets for mounting units, automotive connectors, self-tapping screws etc.

Programming Code

Note: the programming code (ignprgm.hex) for the PIC16F88-E/P microprocessor featured in this project will not be released or be made available on our website. Authorised kit sellers will supply programmed microcontrollers as part of their kits.
For people who do not wish to build the project from a kit, programmed micros will be available from SILICON CHIP for $25.00 including postage anywhere within Australia, or $30.00 by airmail elsewhere.

Ignition Coil Driver

1 Ignition Coil Driver PC board, coded 05104072, 40 x 39mm
1 diecast aluminium box 50.8 x 50.8 x 31.8mm (Jaycar HB-6050)
1 TO-218 insulating washer rated at 3kV
2 IP68 waterproof cable glands for 4-8mm cable
4 M3 tapped x 6mm Nylon standoffs
4 M3 x 15 screws
1 M3 x 10mm screw
1 M3 x 6mm Nylon screw
5 M3 nuts
6 3mm star washers
4 PC stakes
1 2m length red automotive wire
1 2m length black automotive wire
1 2m length green automotive wire
1 2m length brown automotive wire
1 60mm length of 0.7mm tinned copper wire

1 40mm length of 4mm heatshrink tubing

Semiconductors

1 MJH10012, BU941P TO-218 high-voltage Darlington transistor (Q1)
2 BC337 transistors (Q2,Q3)
4 75V 3W zener diodes (ZD1-ZD4)

Capacitors

1 1nF ceramic capacitor

Resistors (0.25W 1%)

1 1.2kΩ
1 470Ω
1 100Ω 5W wirewound

LCD Hand Controller

1 PC board, code 05104073, 115 x 65mm
1 front panel label (or screen printed lid) for case
1 plastic case, 120 x 70 x 30mm with clear lid (Jaycar HB 6082 or equivalent)
1 LCD module (Jaycar QP 5515 or backlit QP 5516)
5 white click action switches (S1,S2,S5,S7,S9)
4 black click action switches (S3,S4,S6,S8)
1 SPST micro tactile switch (S10)
1 4017 decade counter (IC1)
1 DIL 14-way pin header
1 DB25 PC mount right angle socket
1 DB25-pin male to DB25-pin male 1.8m RS-232 connecting lead (all pins connected) (Jaycar WC 7502)
4 12mm long M3 tapped plastic spacers
4 M3 x 6mm CSK screws
2 M3 x 6mm screws
2 M3 x 12mm plastic screws
2 2.5mm thick plastic washers
1 100mm length of 0.7mm tinned copper wire
1 10µF 16V PC electrolytic capacitor
2 10kΩ 0.25W 1% resistors
1 7-way, 8-way or 9-way 330Ω terminating resistor array (8-10 leads). Note: 6-resistors are used in the circuit and one end of each resistor connects to the pin 1 common
1 10kΩ horizontal trimpot (code 103) (VR1)

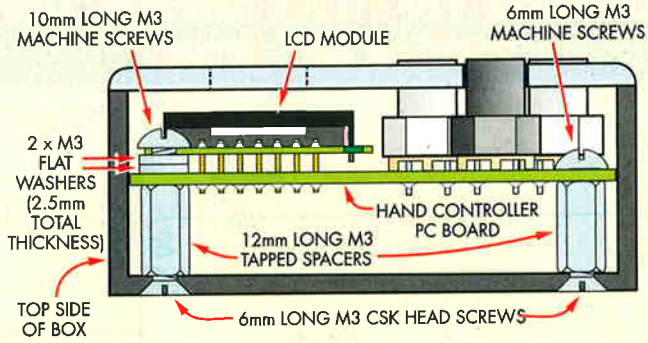

10mm LONG M3 MACHINE SCREWS
LCD MODULE
6mm LONG M3 MACHINE SCREWS
2 x M3 FLAT WASHERS (2.5mm TOTAL THICKNESS)
HAND CONTROLLER PC BOARD
12mm LONG M3 TAPPED SPACERS
TOP SIDE OF BOX
6mm LONG M3 CSK HEAD SCREWS

Fig.20: this cross-sectional diagram shows how the PC board for the LCD Hand Controller is mounted in the case. Note how the top edge of the LCD module is supported on two M3 flat washers.

the case lid (you should get an open-circuit reading).

The earth supply lead goes to a crimp eyelet and this is secured to the inside of the case using an M3 x 10mm screw, star washers and nut. This screw secures a similar eyelet and earth wire arrangement on the outside of the case (this wire goes to the vehicle chassis).

As shown in Fig.18, the remaining wires exit via the cable glands. Cover these leads with heatshrink tubing at the exit points and note that the signal lead must pass through its own separate gland, while the ignition coil (-) lead and the +12V lead pass through a second gland.

Note that, in addition to the heatshrink, these leads may require packing out with tubing so that they are tightly clamped by the glands. **The signal lead must at all times be kept clear of the ignition coil (-) wire to prevent retriggering as the coil fires. Be sure to take it out through its own cable gland and route it well away from the ignition coil wire – see Fig.18.**

Hand Controller

The Hand Controller assembly is shown in Fig.19.

Start by installing the three wire links, including the one under the DB25 socket. That done, solder in the dual-in-line 14-pin header for the LCD module, taking care to avoid solder bridges between adjacent pins.

The SIL resistor array is next. This will have a pin 1 indication at one end (usually a dot) and this end must go towards trimpot VR1. **Note that all the top seven holes must be used, leaving some free adjacent to VR1 if the array does not have 10-pins.**

IC1 can now be installed, taking care to ensure it is correctly oriented. That done, install the two 10kΩ resistors, trimpot VR1 and switches S1-S9. Note that each of these switches must go in with its flat side to the left – see Fig.19. We used white and black switches as indicated on the overlay. S10 is a smaller pushbutton switch that will only fit with the correct orientation.

The 10µF capacitor is next on the list. **This must be mounted on its side to provide clearance when the lid is on (see photo).** Take care with the polarity of this capacitor.

The DB25 right-angle socket can now go in. Make sure it is seated flat against the board and take care to avoid solder bridges between the pins.

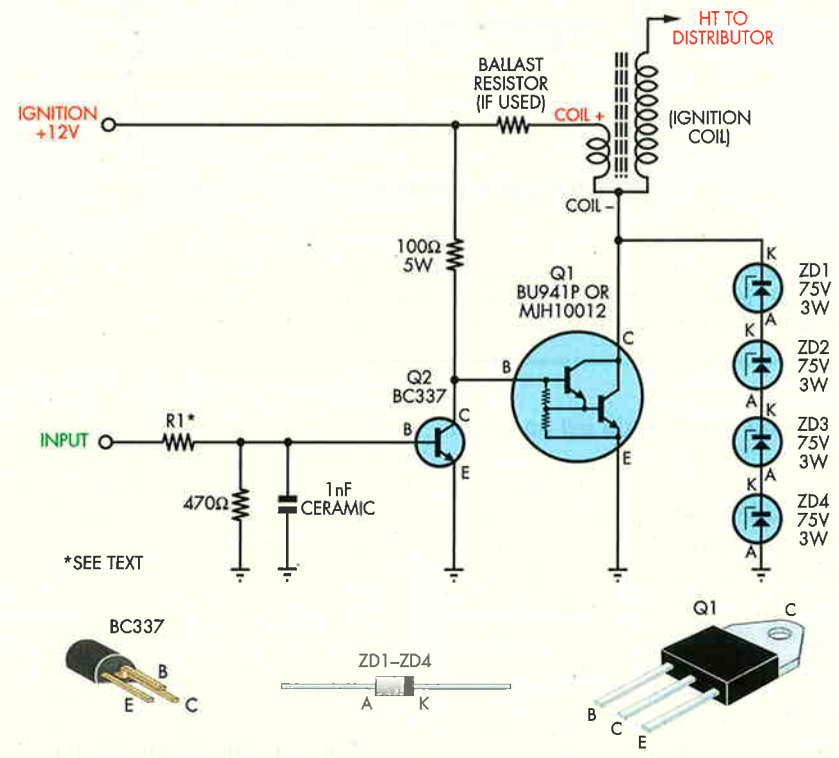
Finally, the LCD module can be installed by pushing it down onto its 14-pin DIL header. Push it all the way down until it is correctly seated against the header, then solder the header pins to the top of the module's PC board.

Fig.20 shows how the PC board is mounted in its case. If you are building a kit, the case will be supplied pre-drilled and with a screen-printed front panel. If not, then holes will need to be drilled in the base of the case for the four board mounting holes and a cut-out made to accommodate the DB25 socket in the side of the case. In addition, the lid will require holes for the switches and a clearance slot for the DB25 socket.

Note that S10's hole should only be about 3mm in diameter – ie, just sufficient for a small probe to actuate the switch.

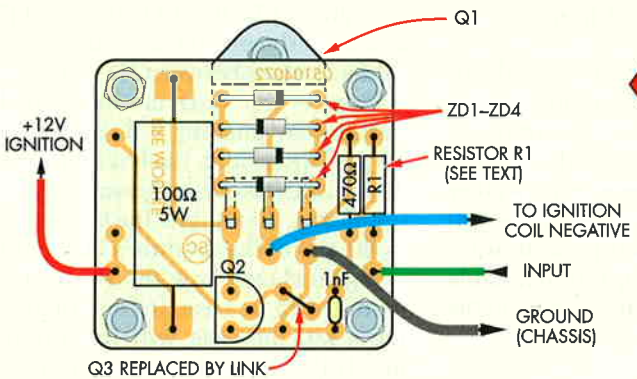
If you already have an LCD Hand Controller as described in "Performance Electronics for Cars", then this can also be used with some minor

Inverting The Firing Sense Of The Ignition Coil Driver



MODIFIED IGNITION COIL DRIVER (TO INVERT THE FIRING SENSE)

Fig.21: this modified Ignition Coil Driver circuit can be used to "fire" a plug when the input signal goes high.



MODIFIED WIRING FOR POSITIVE-EDGE FIRING

Fig.22: this is the modified parts layout. Use a 470Ω resistor for R1 for a 5V input signal and a 1.2kΩ resistor for a 12V input signal.

THE IGNITION COIL DRIVER can be used on its own for other applications; eg, as a replacement coil driver in an existing system. However, in some cases, it may be necessary to change the "trigger sense" of the circuit.

The standard set-up has the coil "charging" when the input signal is high and then "firing" a plug on a negative edge input signal. To invert this level sense, transistor Q3 and the 1.2kΩ resistor are deleted and a link installed between the pads normally used for Q3's base and collector leads.

This effectively bypasses Q3 and the input now drives Q2 via a base resistor (R1) – see Fig.21. Fig.22 shows the revised parts layout for the PC board. Use a 470Ω resistor for R1 when it is driven by a 5V input signal and a 1.2kΩ resistor when driven from a 12V signal.

With this arrangement, the coil "charges" when the input signal is low and "fires" a plug when the signal goes high.

modifications. That earlier circuit is identical to the one described here except that it didn't include the six 330Ω terminating resistors.

This means that all you have to do is add these six resistors between the relevant pins on the LCD module (pins 4, 6, 11, 12, 13 & 14) and ground. These will have to be mounted on the track side of the PC board. The ground connections are best made at pins 7-10 of the LCD module.

Testing

OK, now for the smoke test, starting with the Programmable Ignition Timing Module.

First, apply +12V to the supply input and connect the case to the 0V rail. That done, use your multimeter to check that there is 5V (±0.1V) between pins 14 & 5 of IC1's socket. If this is correct, switch off and install IC1, making sure it is correctly oriented.

Next, connect the RS-232 DB25 lead between the Programmable Ignition Timing Module and the LCD Hand Controller and apply power. You should be greeted with some characters on the LCD. If there are none, or if the display is faint or the contrast is poor, adjust VR1 on the LCD Hand Controller board for best results.

If there is still no display, recheck the parts placement on both PC board assemblies. Check also that the DB25 cable is correct – each pin should be connected through to the same socket pin on the opposite end of the lead.

Assuming all is well, the display shown on the LCD will depend on the position of jumper shunt LK1. Remember that the Settings position will show the settings mode (used when changing parameters), while the Timing position will show the RPM and Load site values against the timing values.

The initial timing values are all set to 0° advance. Check that you can change the values using the switches on the LCD Hand Controller.

Converting your distributor

Finally, note that if you have a distributor with points, you can convert it to a Hall effect pick-up instead, to make it maintenance-free. The details on how to do this were published in our January 2006 issue.

That all for this instalment. Next month, we will describe how the unit is set up and installed in a car. SC

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PRODUCT SHOWCASE

Agilent U1252A True RMS digital multimeter

Describing the Agilent U1252A as a digital multimeter is a little unfair, since it has many more features than the average DMM. Features like true RMS AC measurement, two measurement displays both with 5-digit resolution, inbuilt 20MHz frequency meter and capacitance measurement from 10nF to 100mF (millifarads) are seldom found on DMMs.

Apart from those features, the Agilent U1252A includes a programmable square wave generator, something that we have not seen on any DMM. So here we have a DMM with an output.

To use it, you rotate the range selector switch fully clockwise and there is a square wave and percentage symbol above the "OUT ms" label. The main readout can be set to show duty cycle (default is 50%) or positive pulse width.

You can vary the frequency in quite small steps, from 0.5Hz to 4800Hz using the Hz buttons and you can vary the duty cycle widely as well using the "ms%" buttons.

Output impedance of the square wave generator is 3.5kΩ (maximum) and the amplitude is fixed at 2.8V. This is really quite a useful inclusion and could be handy for all sorts of audio or logic circuit tests.

It highlights the quite different approach taken by Agilent to produce their digital multimeter range. Even the styling and colour are different, with tones of blue and grey instead of the very common bright yellow.

Notice the arrangement of the buttons above the range selector switch. This is also different, to highlight some of the special features. For example, there is battery check switch, which also toggles the blue display backlighting on and off – very handy when you are working in low light situations.

Similarly, there is a Null button which you can use to zero out residual voltages before you make a measurement. Then there is the Shift button which can used when setting up the square generator or to change the mode of the two digital displays.

The Shift button can also be used to change the measurement mode in conjunction with the selector switch. For example, you can switch between Siemens and Ohms for resistance measurements, between Diode Voltage test or Frequency measurement, Temperature or Capacitance and so on.

When you are making voltage measurements, Shift button selects between AC & DC or DC + AC. For AC, the main display can be reading in dB while the minor display reads voltage.

Also unique to the Agilent DMM are 50mV, 500mV and 1000mV ranges for both AC and DC voltage measurements, with very high input impedance greater than 1GΩ. Input impedance for other voltage ranges is the more normal 10MΩ, dropping to 1.1MΩ in dual display.

The Agilent has a very good range of capacitance measurement, from 10nF to 100mF (full scale). By the way, that is not 100 microfarads; it is 1000 times bigger, at 100 *millifarads*! Got some supercaps to check? This DMM will do it.

Accuracy is very high for DC voltage measurements – a basic ±0.03% plus 5 digits from 500mV to 1000V and ±0.05% plus 5 digits for the 50mV range.

Battery life is good because of the auto-off feature but it also comes with a rechargeable battery and charger so Agilent has that point well covered.

The U1252A can be used as a datalogger, with an infrared link and USB interface for PCs. And yes, it comes with software on a CD which also has the full instruction manual.

In truth, there are so many features on this multimeter that it would take quite some time to become fully familiar with all its capabilities. This review is only a small sample. We are very impressed.

Recommended retail price for the top of the range Agilent U1252A is $741.48 including GST.

Contact:
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898 Anketell Rd, Wandi, WA 6167
Tel: (08) 9437 2550 **Fax:** (08) 9437 2551
Website: www.measurement.net.au

VAF's new Octavio 1 will change the way you think about speakers

VAF's new Octavio 1 plays directly from Microsoft's new Zune player and can also connect to a TV, DVD player, game console or other audio source to produce high-quality sound for all home entertainment components. It replaces conventional amplifiers and speakers and removes a lot of clutter from the average room.

It can play loud and deep enough for music to be felt as well as heard and VAF say it's great for use in a home theatre. "If there is bass in the recording, things in the room will shake with no subwoofer required," says VAF's Philip Vafiadis.

Solidly constructed in first grade MDF and uniquely clad in a leather-style finish, it doesn't just look cool it also damps unwanted cabinet resonances. At over 11kg, Octavio 1 is built like a true high-end home entertainment component. It features two powerful long throw 130mm woofers, a 200mm bass radiator and two high-end fabric dome tweeters.

With plenty of inbuilt digital amplification, it also incorporates sophisticated response correction to deliver low distortion, full range sound, flat from under 38Hz to over 20kHz.

At just 110mm deep, it is a perfect match for modern plasma or LCD TVs and one simple control knob can adjust volume level as well as switch between all input sources.

Shipped with every Octavio 1 are three patented acoustic skins. Users can choose a minimalist sleek black, white or pink look, or the very tough powerful leather style 'naked' finish.

If that's not enough, the firmware is also upgradeable via a computer interface in the back panel.

In production and at just US$499, Octavio 1 can be bought through Amazon.com and will soon be available from major specialist consumer electronic retailers.

Contact:
VAF Research Pty Ltd
852-54 North Tce, Kent Town SA 5067
Tel: (08) 8363 9996 **Fax:** (08) 8363 9997
Website: www.vaf.com.au

Circuit Wizard now includes breadboard simulation!

New Circuit Wizard v1.1, from New Wave Concepts, adds a whole host of new features including PC board current flow animation, quality checking for identifying PC board faults and subsystem modelling.

It also includes breadboard simulation, which allows users to select from a wide range of different breadboards and then add components and hook-up test instruments – even connect life-like virtual instruments, for example multimeters and oscilloscopes.

Circuit Wizard's breadboards are ideal for learning about the real things and make it quick and easy to prototype project ideas.

Circuit Wizard is New Wave Concepts' best-selling software package for designing and simulating circuits and PC boards, represented in Australia by 555 Electronics. SC

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Centre Victoria RadioFest is on this month

Now it's time for the Victorians to have their (field) day!

The Centre Victoria RadioFest will be held on Sunday, 22nd April at the Kyneton racecourse, less than an hour from Melbourne, Ballarat and Bendigo. It's intended for radio hobbyists and electronics enthusiasts.

Tickets go on sale at 9am and the gates open at 10am. Inside, visitors will find:

- A trader hall with all major commercial traders.
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- Dipole factory (build your own).
- Undercover trestle table sales area.
- Mini lecture program of interesting topics.
- Come'n'try sniffer foxhunting.
- WICEN (Vic) portable operations on display.

There will be a number of lucky door prizes on the day including a Yaesu FT-857D HF/VHF/UHF mobile transceiver, provided by Vertex Standard (Australia).

Further information can be found at radiofest.amateurradio.com.au

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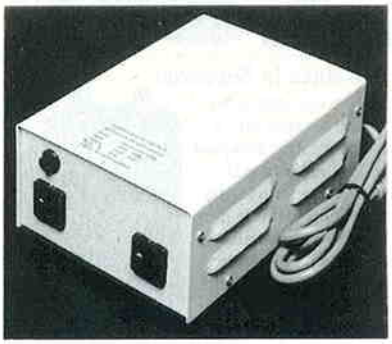

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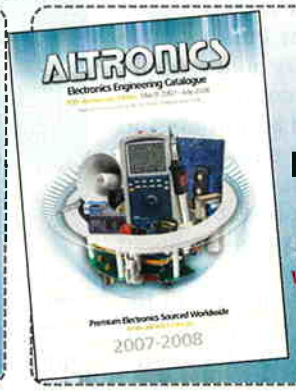

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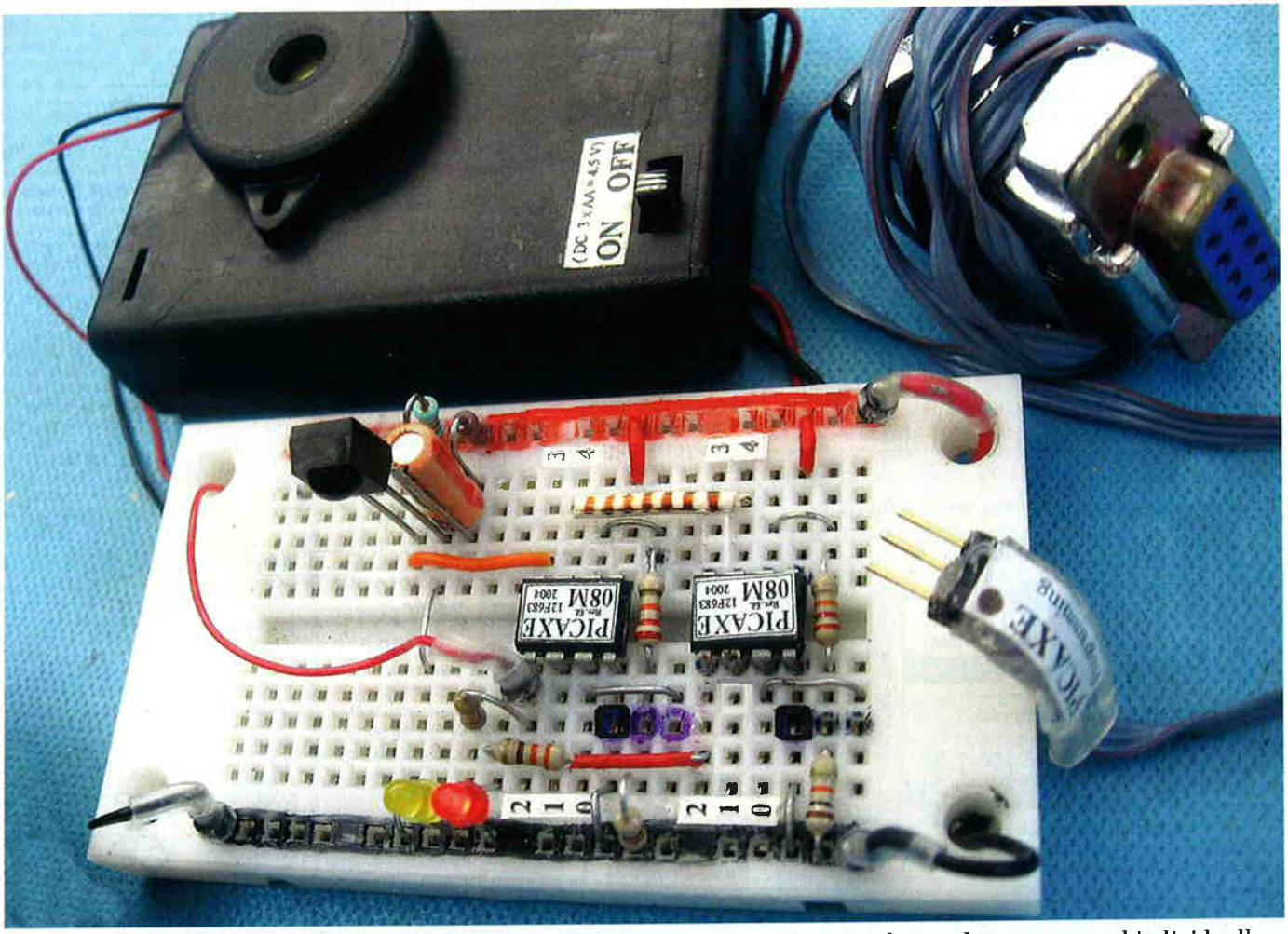
If Intel can do it with a Pentium. . . so can we with a Picaxe!

DUAL CORE PICAXE DATACOMMS

by Stan Swan

What's this? Twin Picaxes? Is this Stan's idea of an April Fools Day Joke? Maybe he's just seeing double . . .



Dual Picaxes! The left Picaxe is the "sensor" while the right Picase is the "doer". Each must be programmed individually.

siliconchip.com.au

In contrast to their ceaseless quest for raw computing speed (typically now 3GHz) computer manufacturers have recently adopted multiple *slower* CPUs, with two ("duo") and even four ("quad") microprocessors under the PC lid.

Doubled-up chips such as as Intel's popular "Core Duo" offer paired microprocessors working at slower speeds (typically 1.5GHz), resulting in lower overall system energy consumption and reduced waste heat.

Given the trend towards ever slimmer and lighter computers, these benefits are especially welcomed, since laptop battery life can be greatly enhanced, weight trimmed and noisy cooling fans reduced in size or even dispensed with altogether.

Paired computing hardware may be akin to a twin engine aircraft – two smaller engines providing more performance than one larger engine – but the concept has even lead to Microsoft's imaginative MultiPoint PC mouse software, potentially offering great appeal in developing world education. (Refer => **www.microsoft.com/presspass/features/2006/dec06/12-14MultiPoint.mspx**)

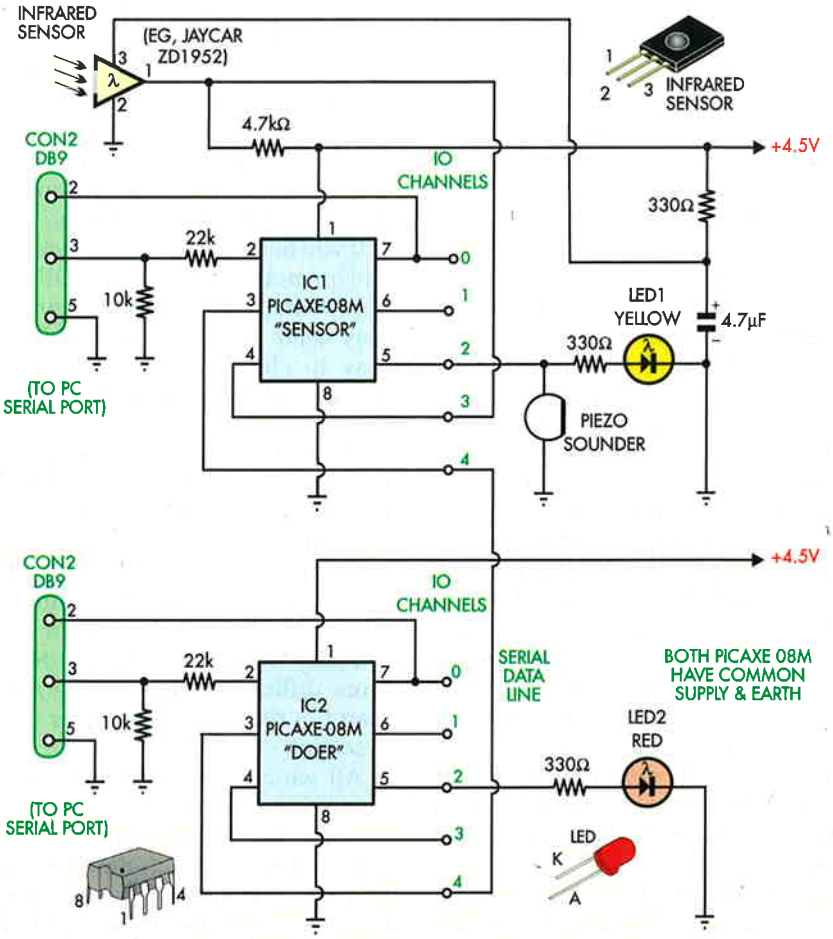
Multiple USB mice may seem like a video game controller octopus but in resource-constrained countries with limited classroom computers, the ability to connect many mice (each with their own coloured screen icon) may allow valuable student collaboration, enhanced learning and simulation. Naturally, programs will need to be specially written to exploit the Multipoint's potential.

Seeing double already?

There's no reason why us Picaxe "little guys" can't adopt the same paired approach, especially since the bare 08(M) chips are now so cheap (~$5) and their inbuilt features allow easy interconnection. Most Picaxe-aware schools and hobbyists will, by now, have bulk stocks of the Picaxe-08M as well, which makes for convenience against ordering specialized ICs.

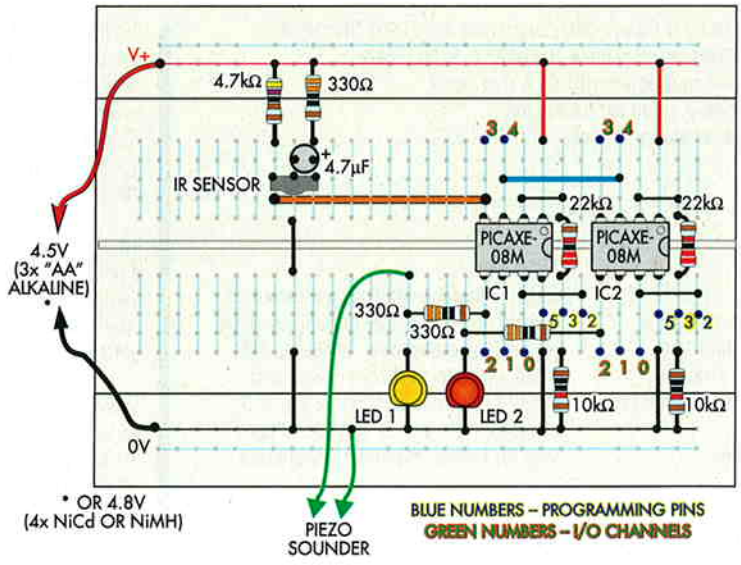
But just why would we want to do such doubling up? Given their modest energy demands (typically only a few tens of milliwatts) it's obviously not going to help fight global warming!

Although having extra system data memory available is appealing (especially for simple data logging), the real Picaxe benefit arises from enhancing



SC ©2007 DUAL PICAXE INFRARED DATACOMMS

A Picaxe driving a Picaxe – not too different an approach now being taken by computer manufacturers. Ours is just a bit cheaper but you definitely won't be able to play "Doom".



Here's how to put it together using our standard Picaxe "breadboard" approach (albeit on a protoboard!). This layout is basically identical to the photo at left.

the sequential nature of their program execution, since limited branching and interruption is normally tolerated.

Several Picaxe commands even lead to the controller just sitting and endlessly waiting for a data signal, with most background tasks agonisingly ignored. It's a bit like neglecting such boring tasks as doing the dishes while awaiting a possible phone call!

Serial input (SERIN) in particular leads to a system hang-up if data fails to arrive and is only normally broken out of by resetting the Picaxe. Future Picaxes apparently may have a timeout setting to overcome this limitation.

The example shown this month utilises a Picaxe 08M pair, with one working as a slaved "sensor" (for Infrared data – in tribute to Robert Adler, the TV remote co-inventor, who recently passed away => www.nysun.com/article/48949) and the other a master "doer" (here accepting serial data and concurrently flashing a LED).

If you've still got supplies of the original 08 then these could be used for the doer but only the 08M can read IR signals.

For those who have just come in and are new to Picaxes, the inbuilt infrared (IR) commands of the more recent 08M have near-revolutionised IR datacomms, with both receiving (via a standard 3-leg receiver) and 38kHz sending (via an IR LED) seamless and cheap.

But rather than using yet another 08M to generate IR codes, the sensor Picaxe here just accepts signals from any standard Sony-style IR remote. Your household junk cupboard is probably stuffed full of them.

If you have several infrared remotes and are not sure if they are still working (perhaps the original equipment they came with has died?) it's quite easy to check to see if the remote has output by aiming it at a video camera.

Most video cameras are sensitive to infrared and the series of pulses will show up as either white or bright green/purple flashes.

And how do you tell if it is a Sony-type infrared remote? If it's not actually from a Sony device (that makes it really easy!) that is significantly more difficult without being able to read the timing of the pulses (eg, on a 'scope).

All we can suggest here is to first determine that the infrared is still working, then try it out with the Picaxe circuit. Perhaps you might be able to borrow a known Sony infrared remote to ensure that the Picaxe circuit is working as it is supposed to.

By the way, sophisticated universal IR remotes are increasingly turning up cheaply in "Dollar Shops", so check them if your home junk box collection doesn't feature a Sony type.

Incidentally, although numeric keypads are available for around $10, their Picaxe driving is quite involved, so it may even be worth using such an IR remote as a "poor man's keypad" when entering numbers to a Picaxe program.

Naturally the wiring will be reduced and the sophisticated 127 codes of INFRAIN2 may appeal, as will full wireless control.

When compared with Bluetooth, ZigBee and WiFi, IR datacomms is very slow and line of sight (LOS) but it offers ranges typically of 5m in sunlight and 20m in darkness and can readily be bounced around and directed by cheap lenses and mirrors. Of course you can still use the remote when watching TV as well!

The "sensor" Picaxe is essentially devoted to just reading (via INFRAIN2) modulated IR signals at the 3 terminal receiver – here a Jaycar ZD1952 (~$8) although cheaper generic versions abound. These powerhouse sensors include an inbuilt detector, limiter, 38kHz band pass filter, demodulator, integrator and comparator. Naturally they need to be looking at the IR source for best response.

A piezo sounder and (paralleled) yellow LED provides user key-push

PICAXE BASIC LISTINGS – IRDO.BAS AND IRSENSE.BAS

You can download from www.picaxe.orcon.net.nz/irsense.bas and www.picaxe.orcon.net.nz/irdo.bas

```
'IRSENSE.BAS for Picaxe-08M, supporting April 2007 Silicon Chip
'Uses 2x 08Ms,one sensing & the other a doing Picaxe.
'See companion program (IRDO) & duo layout
'=> www.picaxe.orcon.net.nz/duo.jpg
'Via => stan.swan@gmail.com  27th Feb. 2007



irsense:
infrain2                    'waits endlessly until IR data received
 if infra >9 then error     'detects non numeric IR remote key push
  high 4:pause 100          'pin set high alerts 'doer' 08M data RTS
   sound 2,(100,10)         'Piezo + parallel LED key press confirm
  serout 4,t2400,(#infra)   'send IR key value as 'infra' (a.k.a. b13)
  low 4                     'handshake pin set low for 'doer' Picaxe
goto irsense                'loop for further IR remote key presses

error:
sound 2,(60,5,0,5,60,5,0,5,60,5,0,5,60,5,0,5) 'fruity wrong key alert
goto irsense
```

```
'IRDO.BAS for Picaxe-08M supporting April 2007 Silicon Chip
'Uses 2x 08Ms,one sensing & the other a doing Picaxe.
'See companion program (IRSENSE) & duo layout =>
'www.picaxe.orcon.net.nz/duo.jpg
'The received IR data values could be used in many ways,
'perhaps as program variables,or actioned under SEROUT
'for LCD display etc. Via => stan.swan@gmail.com

irdo:
if pin4=1 then serial       'RTS alert for serin to accept data
 high 2:pause 100           'Sample ongoing activity-LED flashing
 low 2:pause 100 '          here but could be any Picaxe action
goto irdo                   'loop until RTS pin 4 detected high

serial:
serin 4,t2400,#infra        'Accept serial data pin 4 ('infra'=b13)
 b12=infra+1                'Align IR remote keys & 'infra' values
  if b12=10 then zero       'Test for '0' key which shows as '10'
 sertxd (#b12,13,10)        'Use F8 to display IR remote key pressed
goto irdo

zero:
b12=0                       'Ensure '10' key shows as '0'
  sertxd (#b12,13,10)       'Display on Editor's F8 terminal program
goto irdo
```

feedback, with key presses other than the numeric 0-9 even sounding a fruity incorrect key warning. The correct serial data is then sent out from pin 4, preceeeded by a short HIGH signal to alert the recipient Picaxe data is about to follow.

The "doer" Picaxe here simply flashes a LED as a background task, and continually looks at the status of the serial line (again Pin 4 here) while looping.

If this is sensed high (logic 1) as a voltage sent from the "sensor" Picaxe, then the serial receiving routine is branched to and the data (here just the IR remote key number) accepted.

Although still not entirely foolproof, as the handshaking Ready To Send (RTS) alert may be a false alarm causing the "doer" to endlessly wait, data should usually follow a RTS OK.

The concept is perhaps akin to the phone ringing (thus RTS) as an alert that someone wants to speak with you (data) – it's rare that a ringing phone will not have a caller on the other end of course!

Since the INFRAIN2 values do not align with the actual key label, the number 1 is added to give compatibility.

The 0 key label delivers a 10 on most remotes, so this too has a routine to ensure only a 0 is finally shown.

Leaving the Picaxe programming lead connected to the "doer", and running the editor's inbuilt "F8" terminal program will usefully show these IR key press numbers on screen. Numerous enhancements of course are possible, perhaps using key values as b0-b9 variables in further programs or for LCD readout.

The circuitry is again shown assembled on our now standardised three AA battery powered solderless breadboard Picaxe layout, with supply and ground common to each.

Note that each Picaxe will have to be ***individually programmed!*** The programming lead will need to be swapped to the correct input points and although the order is incidental, ensure the "sensor" Picaxe has IR-SENSE.BAS ported to it, with the 2nd 08M "doer" IRDO.BAS.

If you look at the protoboard photo on page 86 you'll see some purple ink around the three programming input pins (these are also shown clearly in the component layout diagram on P87).

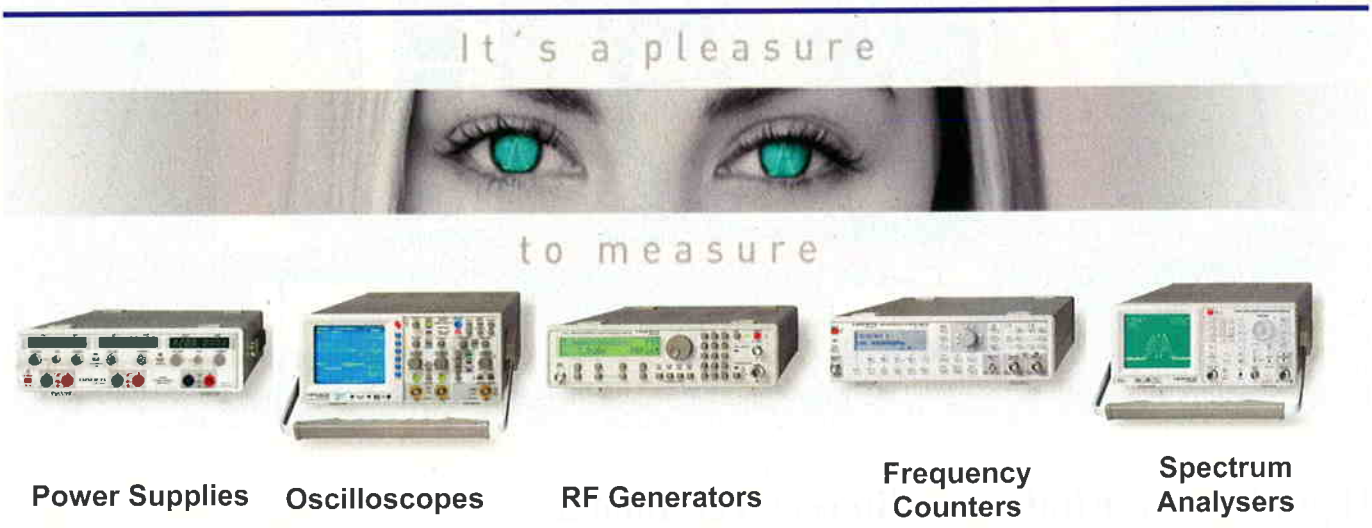
There's no reason why further Picaxes can't be chained together in the style we've shown and serial communicated with to form – gasp - a simple network!

Refer => http://www.kranenborg.org/ee/picaxe/twowirenetwork.htm .

Readers just at the HIGH 1: WAIT 1: LOW 1 stage, who are still exploring Picaxe LED flashing and the like, may find such a concept daunting. It perhaps may be best understood if related to everyday message and voice communications. "Alert. Message for Smith to hand. Message reads "...."etc".

Enthusiasts are encouraged to extend the multiple Picaxe concept, as all manner of control applications, including remote powering, can be performed by simple two-wire (power/signal and ground) links between microcontrollers, that would otherwise need multiple contact switches and numerous wires.

Aside from circuit versatility, the present astronomical price of copper (around $10/kg), means it may make real sense to substitute silicon for costly copper in even modest projects. SC



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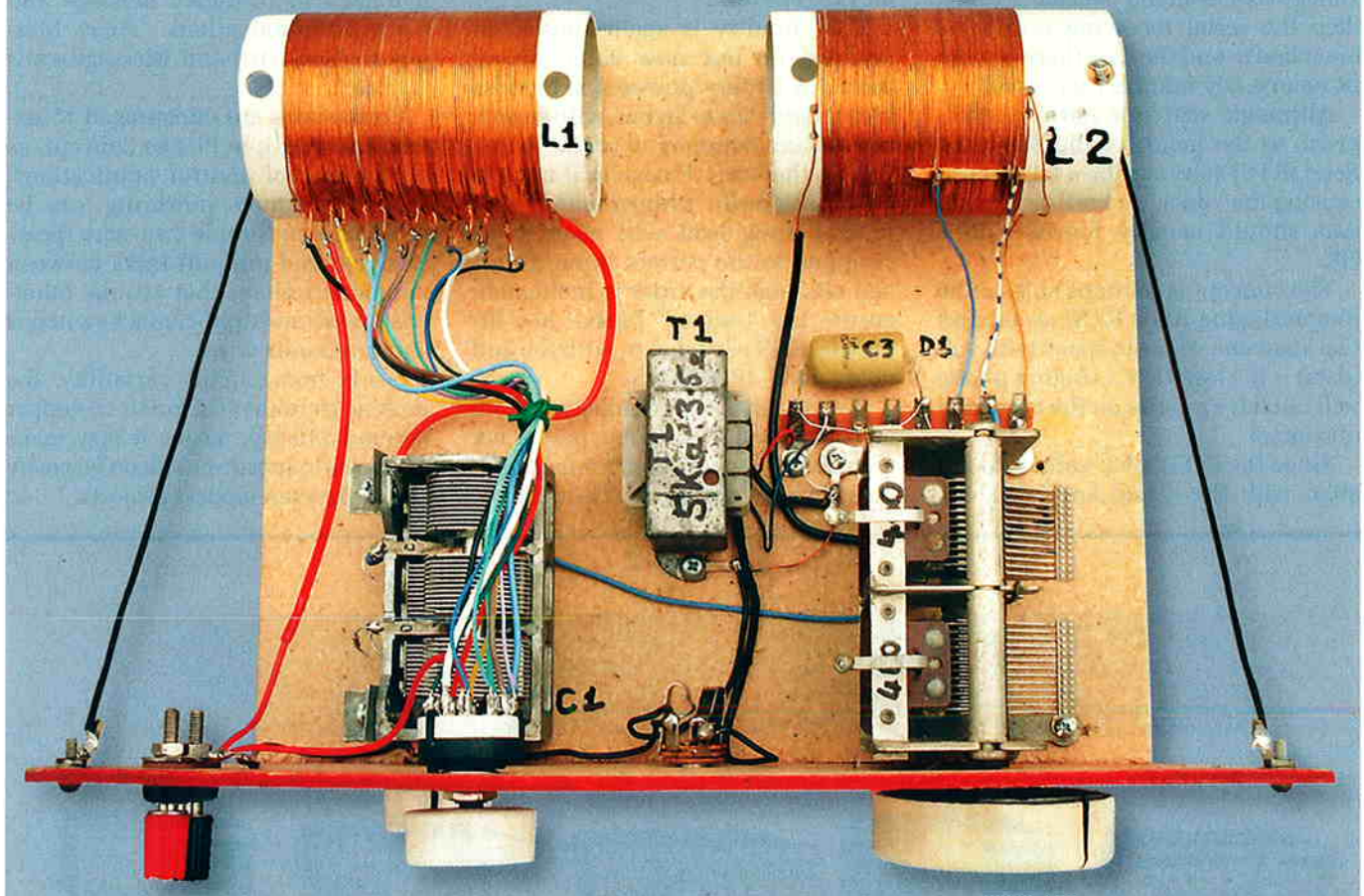
Vintage Radio

By RODNEY CHAMPNESS, VK3UG

How To Build A Super Crystal Set



This photo clearly shows the layout of the super crystal set. It's built on a baseboard measuring 280 x 240mm.

If you've never built a radio receiver, then a crystal set is a great place to start. Here's a design that's very easy to build and get going.

RADIO SETS using all sorts of detectors have been around since the dawn of "wireless" just over a century ago. Very early in the 1900s, one particular detector gained popularity due to its simplicity and relatively high output. This was the "cats whisker" galena crystal detector – hence the name "crystal set".

Basically, this detector consisted of a galena (lead sulphide) crystal held in a metal cup which formed one end. At the other end was a piece of high-tensile wire wound into a short coil and attached to a positioning lever.

The positioning lever was manipulated so that the "pointy" end of the wire – known as the "cats whisker" – made contact with the galena crystal. As a result, it had one annoying deficiency when compared to other detectors – you had to probe around the galena crystal with the "cats whisker" until a sensitive point on the crystal was found. This was fine until something or someone dislodged the "cats whisker" from its sensitive spot, which meant that the procedure had to be repeated.

This was a nuisance which wasn't overcome successfully until detectors like the OA47, OA79, OA91, GEX66 and 1N34A fixed point contact germa-

nium diodes became available. These devices eliminated the "fun" of trying to find the sensitive spot on the galena crystal, as it had all been done by the manufacturer. If the set didn't work, it was usual to look elsewhere for the fault, since these new detectors were very reliable.

However, I remember reading in "Radio and Hobbies" many years ago – in the "Serviceman Who Tells" – about a crystal set that was brought in because it had ceased to work. There isn't much that can to go wrong with a crystal set and is usual to expect the detector diode to be OK. However, in this particular case, the diode had failed, having been destroyed by a strong signal from an amateur radio transmitter next door. Of course, modern devices are much more rugged than those early types.

High-performance sets

Designing a high-performance crystal set isn't quite as easy as it seems at first glance. A number of points need to be taken into consideration for a design to be successful.

The first two essential items are a good, high, long antenna and a good earth. I wrote about antennas and earthing in the March 2003 issue and readers should refer to this to achieve good results.

Unfortunately, the antenna/earth system I'd used for several years was inadequate for crystal set operation. The antenna was only about 6m high at the highest point and about 20 metres long. Its replacement has a maximum height of 9m and is around 27m long. It is also generally higher for most of its length than the previous antenna.

Ideally, the antenna should be up to 15m high and around 30m long but achieving this on a suburban block isn't always easy. However, in my case, the modest improvements in height and length noticeably improved the strength of the received signals.

As an amateur radio operator, I have always been well aware that the antenna in use needs to be tuned to the operating frequency. This is particularly important when the antenna is much shorter than a tuned length, which 99.9% of broadcast band receiving antennas are.

An antenna can be tuned by having a (loading) coil in series with the antenna wire where it connects to the crystal set, with either a tuning gang in series with the coil or a ferrite rod inserted into the coil. The coil may be tapped to suit as well (more of this later). In practice, the addition of an antenna tuning mechanism is extremely effective when it comes to increasing the signal level into the set.

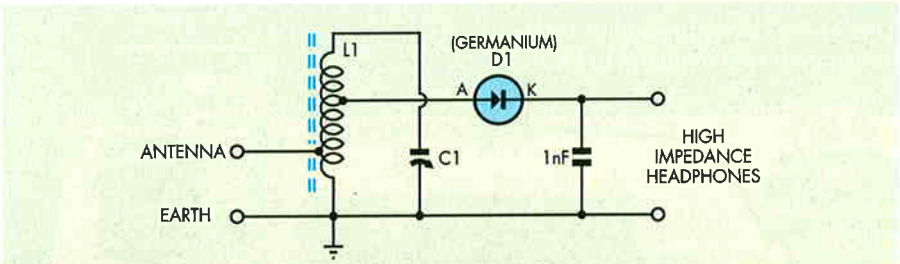


Fig.1: the circuit for a basic crystal set. Coil L1 can be air-cored (see text for specifcations) or can be wound on a 100 x 20 x 5mm flat ferrite rod using 70 turns of 22 B & S enamelled wire tapped at 10, 20, 30 & 40 turns.

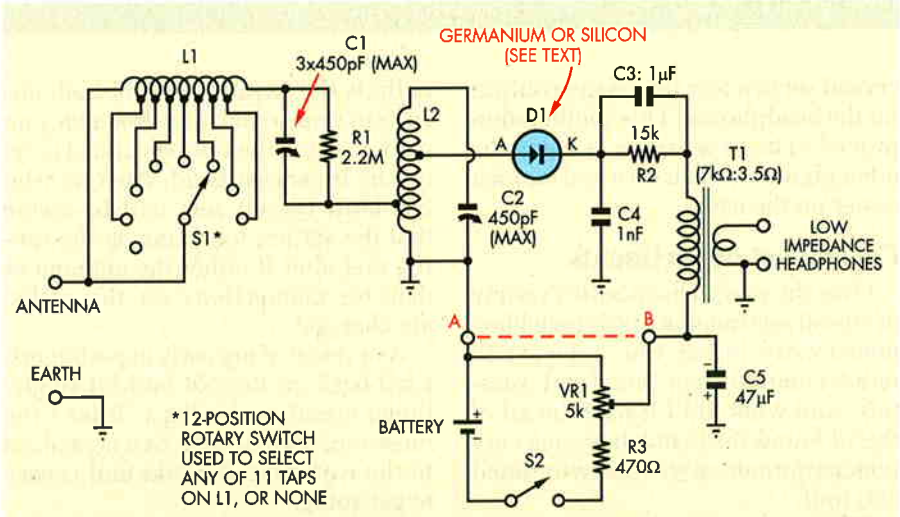


Fig.2: the super crystal set circuit uses L1 & C1 to tune the antenna circuit, while L2 & C2 tune the received frequency. Transformer T1 is included for driving low-impedance headphones. Also included is an optional detector bias circuit consisting of VR1, switch S2, the 47µF capacitor, the 470Ω resistor & the battery – see text.

When it comes to making coils, both the coils and coil formers need to be low loss. I've found that 60mm-diameter white PVC tubing (available from plumbing and hardware stores) is quite satisfactory for the job. By contrast, cardboard coil formers can attract moisture which increases coil losses.

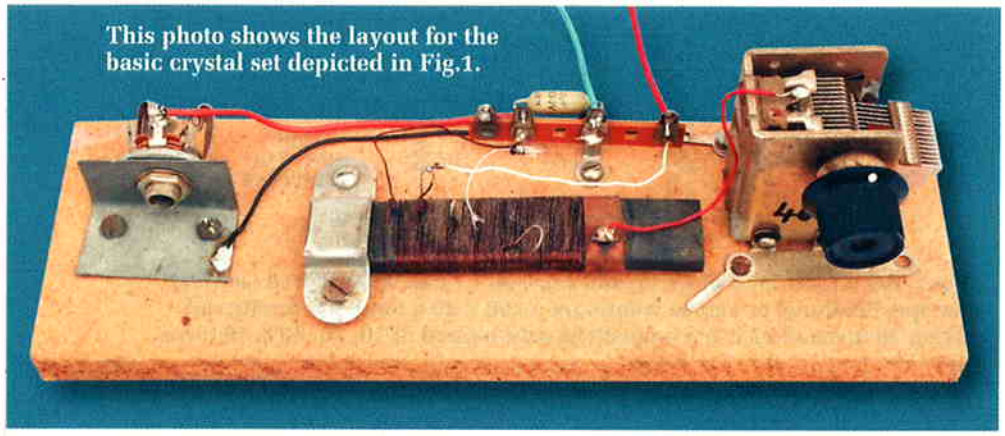
It is important that both the detector and antenna are matched to the tuned circuit(s) for best performance. This is achieved by simply connecting the detector and the antenna to the coil taps which provide optimum matching.

Detector efficiencies can vary considerably and you can experiment with various germanium and silicon signal diodes is to achieve the best results. Note however, that silicon diodes usually require a biasing voltage to operate efficiently as detectors.

Headphones

Good quality headphones with good sensitivity are also needed to get the best performance from a crystal set. I have a pair of 4kΩ Kriegsmarine headphones which work well but are quite uncomfortable to wear. I also have a pair of Browns "F" type headphones but these have a relatively low impedance of about 150Ω. And I have a couple of other headphones of rather mediocre quality and a pair of 8-ohm padded stereo headphones.

In the end, I wired up the phones socket on the crystal set so I could plug my stereo headphones into the set with the ear pieces in series. I also used a speaker transformer (as used in valve radios) to transform the high-impedance output from the


This photo shows the layout for the basic crystal set depicted in Fig.1.

crystal set to a low impedance output for the headphones. This combination proved to be as sensitive as using the other phones on their own and is much easier on the ears.

Crystal set experiments

Over the years, I have built a variety of crystal sets ranging a little matchbox monstrosity (mine was anyway) to rather complex twin-tuned coil varieties. And what did I learn from all of this? I found the match box set a very poor performer, as was the twin-tuned coil unit.

The latter unit used a 2-gang tuning capacitor and was a failure because, at that time, I didn't understand that the two (identical) tuned circuits needed to "track" each other. In operation, each tuned circuit was being detuned according to where the antenna and detector connections were made to the respective coils.

"Tracking" for those new to vintage radio is the requirement for both circuits to tune to the same frequency no matter where the tuning control is set on the broadcast band. Anyone who has built crystal sets will be aware that the station locations on the tuning dial alter if either the antenna or detector connections on the coil(s) are changed.

As a result of my early experiments, I fell back on the old faithful single-tuned circuit – see Fig.1. It isn't the most sensitive or selective crystal set in the world but it works and is easy to get going.

In my case, I built one with a normal air-cored coil and another using a ferrite rod as the former for the coil winding. They both worked but would only receive two stations clearly in the Shepparton area – the old 3SR 2kW station on 1260kHz around 20km away and the local 500W community station on 1629kHz about 10km away.

If you want to experiment with a ferrite-rod coil crystal set, the coil information is as follows: 70 turns of 22 B & S enamelled wire tapped at 10, 20, 30 and 40 turns on a 100 x 20 x 5mm flat ferrite core. The experimental layout can be seen in one of the photographs.

The photo shows the author's Browns "F" type headphones plus two other miscellaneous units. High-impedance headphones (eg, 4kΩ) are necessary for the circuit shown in Fig.1.

Super crystal set

I've always wanted to design and build a "super crystal" radio receiver, so I did some experiments back in 2002 with methods of tuning the antenna. My early experimental antenna tuning system was described in the March 2003 issue of SILICON CHIP. Using this device, I could detect four radio stations instead of the single station I could normally receive on my "standard" crystal set.

By this time, I had a reasonable idea of what might work well but without being too complex. However, I didn't want to make a set which used exotic parts, or parts that were hard to make, or one that was so complex that a university degree was necessary to "drive" it.

In particular, a twin-tuned circuit would not be suitable, as getting the two tuned circuits to "track" across the broadcast band using a single control would be impractical. By contrast, it would work if I used two independently tuned circuits but that would add additional complexity and the tuning would be a nightmare. And for best performance, the coupling between the two tuned circuits would need to be carefully done otherwise its performance would be inferior to a crystal set with a single tuned circuit.

As stated, I had previously had quite good success using a loading coil in series with the antenna. This then connected to an antenna tap on the tuning coil. However, it was purely experimental and although it worked well (and improved the number of stations received), it was touchy to adjust.

In particular, the position of the ferrite rod in the coil was quite critical and it had to be adjusted for each station received.

What it did show was that the "Q" of the loading coil was quite high. For those unfamiliar with "Q", it is basically a term relating to the quality (or "sharpness") of a tuned circuit. The higher the "Q", the better a circuit is at discriminating between stations across the broadcast band. After all,

we only want to listen to one station at a time!

Detector bias

Some crystal set designs use a battery and a potentiometer to bias the detector to the point where it just conducts. The reason for this is quite simple.

Diodes all need a certain amount of voltage applied to them before they conduct. As a result, if we apply a DC voltage to a signal diode so that it just conducts, the diode will be in its most sensitive state and will thus give good performance in a crystal set.

This "bias" voltage varies according to the diode used. For example, silicon diodes such as the 1N4148 and the 1N914 require around 0.6V of positive bias to operate, while a germanium diode only requires about 0.2V of bias. On the other hand, the OA47 diode I've used works quite well with no forward bias, which has kept my crystal set just that bit simpler. Your own experience may be different, however so be prepared to experiment.

By the way, transistor radio detectors often use forward bias to improve sensitivity. (Editor's note: forward bias on a diode detector also reduces harmonic distortion).

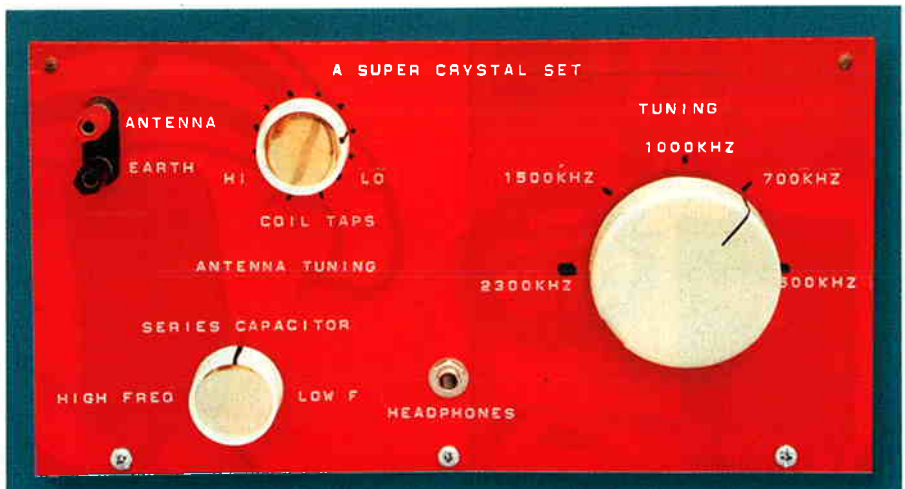
Detector load

The load that the detector works into is usually a pair of headphones which may have between 2kΩ and 4kΩ total resistance. However, the diode will be more efficient if it works into a higher load resistance and some designs use a resistor of about 15kΩ in series with the headphones to achieve this. In addition, a capacitor of around 1µF is placed in parallel across the resistor so that the audio is not noticeably attenuated.

Although my 4kΩ headphones are good performers they are uncomfortable, so I compared the performance of other headphones against the 4kΩ pair. As stated above, I ended up using low-impedance stereo headphones fed through a speaker transformer. (Editor's note: we also recommend the 32Ω earphones supplied with iPods and MP3 players).

Putting it all together

The set described here is not only easy to build and operate but outperforms many other so-called high-performance sets.



This view shows the front-panel layout for the super crystal set. A good aerial and earth are necessary to achieve good performance – see text.

Fig.2 shows the circuit. L1 & C1 tune the antenna circuit, while L2 & C2 tune the received frequency. Transformer T1 is included for driving low-impedance headphones, while the optional detector bias circuit consists of VR1, switch S2, a 47µF capacitor, a 470Ω resistor and the battery.

The set was built on a 12mm-thick particle board measuring 280 x 240mm. This is fitted on the underside with four self-adhesive felt pads (available from hardware stores) to keep it clear of the bench.

The front panel is made of thin plywood measuring 300 wide x 160mm high. This was given several coats of red paint from a spray can and the labelling on the front panel completed using red Dymo® embossing tape (to match the paint job).

Tuning capacitors

Tuning capacitors can be scrounged from old valve radios that are not worth restoring. For C2, I used one section of a 2-gang full-size 460pF tuning capacitor. This has a 3/8-inch shaft which suits few knobs (and certainly none of my collection). It did, however, have a dial drum which was left on. I fitted a cut-down top from a tin of cream spray paint over the top of the dial drum (it fitted perfectly), which makes it look better and acts as a "handspan" dial.

I was more fortunate with C1 which is a 3-gang 450pF per section tuning capacitor, as this had a ¼-inch shaft. All three sections of the capacitor are used in parallel. The only disadvantage with this tuning gang is that it has a reduction drive, which means that more than a full turn of the knob is required to go from minimum to maximum capacitance.

C3 is a 1µF polyester or greencap type, while C4 is a 1nF unit. The voltage ratings of these capacitors can be quite low.

Resistors & switches

Resistor R1 is used as a "static leak". Its purpose is to prevent a high-voltage static charge from building up across C1 (eg, during storms) which could lead to flash-over. Note also that if a particularly big antenna is in use, it would be advisable to disconnect and earth it when the crystal set is not being used.

Resistor R2 (15kΩ) is the DC load for the detector. Both R1 and R2 can be 0.5W or smaller. If detector biasing is used, R3 can be a 0.5W unit, while VR1 can be a standard 1kΩ linear trimpot or a normal potentiometer. VR1 will not normally require readjustment once set.

S1 is a 12-position switch which selects one of 11 tappings on L1. Only 11 positions are used; the 12th is left with no connection so that the whole of L1 is in circuit. S2 (if fitted) turns the detector biasing on or off as required.

T1 is a standard speaker transformer with a 5kΩ or 7kΩ primary impedance and a 3.5Ω secondary winding. This drives two 8-ohm headphone earpieces in series, so that the reflected impedance to the primary from a 16-ohm secondary load is at least 20kΩ. Within reason, increasing the reflected

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This view shows the author's stereo 8Ω headphones at right and a pair of 4kΩ Kriegsmarine headphones at right. The latter can be used with the basic crystal set circuit shown in Fig.1.

impedance will assist in maximising the audio output of the receiver.

Winding the coils

Now we come to the all-important coils (ie, L1 and L2).

First, L1 is wound on a 100mm length of 60mm-diameter white PVC pipe. In my case, I wound on 102 turns of 0.63mm (22 B&S) enamelled wire over a length of 70mm. In hindsight, though, around 110 turns would have allowed somewhat more adjustment range to tune the antenna system.

When winding L1, it should be tapped every seven turns and there should be 12 tapping points in all, starting right from the antenna end of the coil. If your antenna is significantly different from mine, then the number of turns on this coil to achieve optimum tuning will vary accordingly.

L2 is also wound on a 100mm x 60mm-diameter white PVC water pipe and consists of 80 turns of 0.63mm (22 B&S) enamelled wire. This winding is spread over 60mm of the former's length and the coil is tapped at 3, 6 & 35 turns from the "earthy" end.

In my case, I found that using turn three as the tap gave good results. You will need to experiment here – you may need even fewer turns to the first tap if your antenna is larger than mine. Note that the correct position may vary from the high-frequency end of the band to the low-frequency end.

Because the detector load is relatively high, it's possible to connect the detector to a tap quite high up the coil. I found that 35 turns was optimum for best performance in my receiver.

As can be seen from the photos, different tapping methods are used for the two coils. For example, L1 has the wire raised away from the former and twisted to make each tapping. By contrast, on L2, a match is slid under the wire at the first tapping point and is then slid along the winding to go under each successive tapping point as the coil is wound. This is the neater of the two methods but is difficult to do effectively if the winding is long and has lots of tappings.

With either method, it is necessary to thoroughly clean the enamel off the wire at the tapping points so that a good soldered joint can be made. This can be done by scraping away the enamel using a sharp utility knife.

Receiver layout

The parts layout on the baseboard is not critical, although the coils should be mounted at the back of the receiver for ease of access. The accompanying photos show the author's unit.

In my case, tuning coil L2 was mounted at the right rear of the baseboard, with L1 in the opposite rear corner. It's important that L1 is kept several centimetres away from L2, to minimise unwanted coupling between them.

Diode biasing

As mentioned earlier, some diodes (particularly silicon signal diodes) require about 0.6V of positive bias

to maximise sensitivity. Normally, without diode biasing, points A and B are connected together on the circuit. Conversely, if forward biasing is used, points A and B are separated and the small circuit consisting of B1 (a 1.5V dry cell), toggle switch S2, a 470Ω resistor, a 1kΩ trimpot (VR1) and a 47µF electrolytic capacitor added between these two points.

This circuit is easily adjusted. Switch S2 is closed and trimpot VR1 is adjusted for best volume – simple.

Summary

Those who have never built a crystal set radio before will find this little set worth the effort. It works well, isn't difficult to tune and provides good headphone volume on all local stations.

For best reception, use a high, long antenna that's clear of buildings and trees. A good earth is also necessary and a pipe driven about one metre into the ground and kept damp should suffice.

Finally, if you wish to read about other people's designs, the following list makes a good starting point:

(1) Look on the Internet. Typing "crystal set society" into Google will give you many interesting sites (and lots of designs) that you can explore.

(2) Look in SILICON CHIP for October 1988 (crystal set), March 1990 (wave traps), October 1994 (Hellier Award crystal sets), March 2003 (antennas).

(3) Look in "Electronic Australia" for June 1988 (crystal set), July 1994 (crystal sets), November 1998 (coils) and July 2000 (crystal set).

(4) An excellent Australian book on crystal sets is "Crystal Sets 'N' Such" by Bob Young (7 Hayes Rd, Swanpool, Vic. 3673). He has a few available for $19:95 posted in Australia. SC

Photo Gallery: Targan Airmaster

MANUFACTURED BY TARGAN ELECTRIC PTY LTD in 1933, the Airmaster was a 3-valve TRF receiver in an upright wooden cabinet. It used the following valve types: 57 detector; 59 audio output; and 80 rectifier. Photo: Historical Radio Society of Australia, Inc.

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PIC Programmer does not work with LCD

I purchased the PIC Programmer & Testbed kit (SILICON CHIP, January 2001) from Dick Smith Electronics and have built it. My problem is that I cannot get the LCD module to work. No matter what I try, I am not getting a thing on it.

I am using the provided program and I know the PIC chip has been programmed properly as the chaser works. I get nothing from the LCD. I purchased the product with the intention of doing programming on the system to write to the LCD but I cannot get it to work.

Is there anything that you can do to help me in this regard? I also purchased another LCD module with the hope I might have blown the first one up but it didn't work either so I am assuming I have a problem in delivering the signals. I have looked very carefully at the soldering for any problems but there are none. (S. O., via email).

● This suggests a connection problem between the main circuit board and the LCD module. Here's a troubleshooting procedure:

(1). Start by checking that you have JP1-JP11 in the "b" positions. This connects the micro's port pins to the LCD connector rather than the LEDs.

(2). Try varying the CONTRAST adjustment (VR3) when running the test program. If this has no effect, use your multimeter (set to VOLTS) to measure between pins 2 & 3 of CON4 while varying the pot from minimum to maximum; you should get a reading of 0-5V.

(3). If the above turns up nothing, then power off and use your meter (set to OHMS or CONTINUITY) to verify each of the connections to the LCD module. We suggest that you remove the PIC chip and measure between the ZIF socket pins and the pads on the rear of the LCD module. This checks all connections between the two units.

Alternative use for ECG project

Thanks for the Electrocardiograph project (SILICON CHIP, February 2005) which has provided quite interesting results. Apart from recording the actual heart beat waveforms using conventional electrodes, it turns out that it can also be used to sense heart beats using red and infrared diodes with a sensor attached to a finger, which also provide clear pulsing blood flows.

However, there are problems in trying to analyse the results. The ratio of the red and IR values gives an indication of the oxygen content of the blood (refer to Oximetry on the internet). I tried using a PIC08M to extract pulse information from the analog waveform to the ADC but this proved unreliable and seemed pointless when it was already being done in the ADC anyway.

However, the ADC output is at 38,400 bps which seems a bit fast for a PIC08M microprocessor and the ECG Sampler refuses to operate at the other listed settings of 9600 and 28,800.

Can you suggest a means of accessing the ADC output at these lower speeds or dare I ask for access to the source code? (D. O., via email).

● The sampling rate of the ECG Sampler is directly under the control of the firmware in the PIC16F84 micro, so you would really have to alter the firmware to achieve your aims. The source code is available on our website (ecgsampl.asm) and is fairly well commented, so if you're used to programming PICs it will hopefully make your job a bit easier.

The role of Diacs in lamp dimmers

I wonder if you can explain to me what a Diac does in a Triac lamp dimmer circuit? I just don't see why a resistor won't do. If it is needed, why don't they incorporate a Diac in to the Triac package? (C. B. via email).

● Essentially a Diac is a symmetrical breakover device. Up to 30V or so in either direction it is an open-circuit but once the breakover voltage is exceeded, it breaks down to a low negative resistance. This is ideal to discharge an associated capacitor to

Ultrasonic Eavesdropper Could Check Power Line Insulators

Recently I had a chance to look at an "insulator checker" that the South Australian Electricity Trust has for locating noisy insulators. Basically, it looks like an ultrasonic microphone located at the focal point of a parabolic dish about 400mm in diameter. This is fed into an amplifier behind the dish to drive a small speaker as well as a meter. I assume that the amplifier is tuned to a specific frequency band in order to reject noises that are not required.

I believe this device is very effective from reports I have heard.

I wonder if you have ever described such a device or whether your Ultrasonic Eavesdropper (SILICON CHIP, August 2006) could be modified for the purpose? I would think this device would be of interest to many amateur radio operators as well as folk with severe power line interference to TV reception. (A. H., Kingston, SA).

● Many years ago "Electronics Australia" had a feature article on the use of an ultrasonic microphone and dish for checking high voltage insulators. The principle is exactly the same as in our Ultrasonic Eavesdropper.

Antenna Fundamentals

I have very poor knowledge about antennas; just enough to know that the design is linked to wavelength or the frequency. Could you please explain in basic terms what is the relationship between the size of the horizontal rods and the wavelength that is received by the antenna? What is the ratio between rod length and wavelength? Or is it put in terms of frequency?

I have noticed the older type of TV antennas have rods with varying length whereas the new UHF antennas seem to have rods of a standard length. Could you please help me to understand why antennas are like this? (B. D., Auckland, NZ).

● In essence, virtually all (except long-wire) antennas depend on resonance to work. Their elements are typically about a quarter of the signal wavelength in the frequency bandwidth of interest.

For example, a quarter-wave dipole designed for operation at 100MHz (in the FM band) will be close to one quarter of the signal wavelength at 100MHz. This is calculated by dividing the frequency into the speed of light (ie, the speed of all electromagnetic signals). Therefore, wavelength = 3 x 100,000,000/100,000,000 = 3 metres. One quarter of this 75cm. According to this, a dipole cut for 100MHz will be 75cm but in practice will be slightly shorter due to "end effect".

There is a huge amount of information on this topic available on the internet.

trigger the Triac into conduction, in a light dimmer circuit. Some Triacs do incorporate a Diac.

Soldering/clothing iron timer

Have you ever published a circuit for a soldering/clothing iron timer? I envisage it working along the lines of the "vigo" (Vigilance Device) found on trains. After a settable delay, it would alert the user with sound/light and unless the user acknowledges the alarm by pressing a button within some interval, it will cut the power. (D. H., via email).

● Have a look at the Universal Safety Timer for Irons and Kettles, in the August 1990 issue of SILICON CHIP. We can supply a photocopy of the article for $9.50, including GST and P&P (Australia).

Electrical safety with fish tanks

Is there a device available that could be plugged in-line between a power outlet and the power cord of some electrical machine that will display the amount of current being used and then sound an alarm if it drops below a threshold? Even if the power cuts out? There are two reasons I want one:

(1) My marine fish tank has 12 devices plugged into power boards with cutouts. It is important to know if the power cuts due to one of the boards tripping or if the safety switch at the house's power box is tripping.

(2) I need to figure out why our electricity bills are so high. My wife suspects it is my marine fish tank. There are six big pumps, a water chiller, some heaters and some controllers that turn them on and off, so the current load varies and I want to check the different configurations. I can calculate it theoretically but I want to see actual figures. I do have a multimeter but it is a bit awkward trying to use that with mains power.

My second question relates to current leaking from the water chiller. Even if it has not been activated by the controller, current leaks into the fish tank. I had an electrician measure it and although he said it was high, it was within the safe limits. However, I can feel it when I put my hand in the tank, especially through any cut in my hand, and leaking current has been blamed for certain illnesses in fish.

I put a "sump grounding probe" in – a titanium probe in the (salt) water that is connected to a stake banged a metre into the ground outside. It reduced the feeling of electricity a fair bit but did not completely remove it. Do you have any suggestions on how to deal with this?

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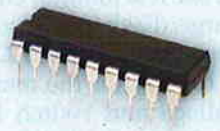

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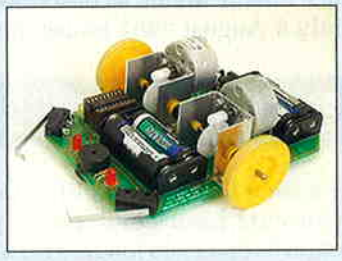

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Serial I/O Controller & Analog Sampler

I have just purchased the Serial I/O Controller & Analog Sampler kit, from the November 2005 issue. I want to use it to monitor and control the charge/discharge of some large batteries – a total of 48VDC at 700A. I want to monitor the temperature and voltage and switch load and charger during daylight and night.

To do this, I need to be able to locate the temperature sensor and LDR remotely. Is this OK or will the long leads of up to five metres cause a problem?

Also, what would I need to do to monitor up to 52V DC at the analog input port (normally 25V max) – a voltage divider? I assume software changes would be required in the Windows program as well. What about code in the PIC? (J. K., via email).

● You should be able to mount the LDR remotely if you use shielded cable for the connection. Miniature 2-core microphone cable would be suitable. Wire the cable shield to ground. A 1kΩ resistor in series with pin 3 of the micro will help to protect it in the event of static discharge to the long cable run.

The second analog input can be modified to accept 52V by modifying it as follows:

(1). Change the 330kΩ resistor to 110kΩ.
(2). Change the 100kΩ trimpot (VR1) to 2kΩ.
(3). Break the track between VR1 & LED4 (the ground connection) and insert an 11kΩ resistor in series with the pot.

The above changes will give an input range of about 49V-59V full scale.

Yes, you will need to modify the Windows software to get the correct reading. The source code for the software is written in VB5. The PIC firmware should not require modification.

It really concerns me that so many cheap submersible electrical devices (pumps and heaters typically) are being sold to fish tank owners – often kids. I've had one decent electric shock from a submerged pump that had a cracked housing. The entire fish tank water became live and when I was cleaning the inside my elbow touched the grounded light housing above causing the shock.

Sump grounding probes exist but are rarely known about and even though I have managed to get one, I'm not sure that I'm using it properly as it isn't dealing with the current leaking from the chiller. (S. G.,Beachmere, Qld).

● As far as measuring the power consumption of your fish tank set-up is concerned, you could build our Appliance Energy Meter, as described in the July & August 2004 issues. It will record instantaneous power and energy consumption over a period. However, it will not provide any alarm if there is a power cut. Perhaps that feature could be provided by the Aquarium Temperature Alarm described in the September 2006 issue. However, note that the Temperature Alarm would need to have battery backup otherwise it also would be rendered useless in the event of a power interruption.

There is no doubt that your marine fish tank set-up could be responsible for a large power bill, especially if you are growing corals and need high-intensity halogen lights. The continuous power draw in a typical set-up could easily be 500 watts or more and over a 3-month period this could easily cost $140 or more, depending on your power tariff.

As far as current leakage from heaters and chillers is concerned, the only safe way to tackle this problem is to run the whole system via a safety switch or RCD (residual current device). This will kill the power to the system if the leakage current exceeds a safe value and could prevent a nasty shock or fatality. Mind you, this will also mean that you need the Aquarium Temperature Alarm, as noted above.

Marantz Amplifier Needs Loudspeaker Protection

I have a Marantz amplifier in for repair and it has a faulty speaker protection IC that is no longer available. In your experience, how safe is it to "force" the protection relay? There are a number of direct-coupled amplifiers without this provision.

I realise that the IC detects DC offsets, transistor failure, etc which can damage the speakers. There are no existing faults. Your comments would be appreciated. (I. M., via email).

● We are not sure what you mean by "forcing" the relay.

We think that all high-powered amplifiers should have loudspeaker protection. The consequences of an amplifier failure can be exactly as described in this month's Serviceman's pages.

If you cannot get the original IC, we suggest you rebuild the circuit along the lines of one our loudspeaker protectors as described in August 2000 or April 1997.

Comparing light outputs from LEDs

The light output of LEDs is sometimes stated as so many milliCandelas or Candelas. Recently, I have seen LED light output stated in Lumens. Spotlights are rated as so many watts or in varying amounts of candlepower; eg, 500,000 candlepower.

Could you explain the difference between these units and give some sort of equivalence table so that the light output from various sources can be effectively compared? (G. H, Camden, NSW).

● The lumen is a measure of total light output, whereas the candela is a measure of the intensity of a light source in a given direction. While there is no general-purpose conversion between these two essentially different measurements, it might be possible to make some rough comparative calculations if the beam angle is known.

Check out this website to get an idea of the maths involved:
http://autolumination.com/brightness.html

Extending the frequency counter

SILICON CHIP has given us a good design for the 50MHz frequency counter, now thoughtfully and usefully modified to accommodate pre-scaling and the display of frequencies in the GHz range (February 2007). But spare a thought for those of us who need really good resolution in the audio range: ±1Hz at around 160Hz, for example, is just not close enough for critical work.

Could SILICON CHIP publish a neat little multiplier (say, x 100) to insert between the signal and this counter? And while I have the opportunity – how about a decent sweep generator project to cover the frequency range from 5Hz to 50kHz, as a means of testing pre or main amplifier frequency responses? (J. G., via email).

● We have not published a multiplier project but we did publish a good circuit to do exactly what you want. It was a "Frequency Multiplier for LF Measurements" in the Circuit Notebook pages of the February 2004 issue.

An audio sweep generator could end up being quite a complex project. Instead, you could download a tone/sweep generator program from the internet, such as **http://www.nch.com.au/tonegen/index.html?ref=google&ref2=c10a1&gclid=CKXgjdrxrooCFRTWYAod3zeqsw**

Burglar alarm questions

I am a year-12 student and about to start my major project. It is going to be the PC-Controlled Burglar Alarm System in the February 2006 edition but I have a problem with some PIRs: they have positive, negative and two alarm terminals. The PC board in the magazine has provision for positive and negative (ground) and one terminal for the alarm signal. How does this work? How does it detect if the circuit is NO or NC? Do I need different PIRs? (N. P., Ulladulla, NSW).

● Many PIR (Passive infrared) sensors have four terminals. Two terminals provide power for the sensor's internal circuits and are often marked "+" (positive) and "-" (negative). These two terminals connect to the "+12V" and "GND" terminal block outputs on the alarm board.

The second two terminals provide "normally open" (NO) and "normally closed" (NC) outputs. Only one of these must be connected and it's not important which one you choose. As described in the article, the NO or NC output of a sensor connect to one of the "ZONE" inputs on the alarm board.

When running the alarm software, be sure to select "N/O" or "N/C" in the "Configuration" panel to match your sensor wiring. SC

Notes & Errata

Ultra-LD 2 x 100W Stereo Amplifier (November & December 2001, January 2002): in the "Switching On The First Time" section (pages 71 & 72) of the third part of the series, a step-by-step procedure was presented for connection and testing of the various components of the system. A slight error in the sequence prevents the DC fault protection test from operating successfully.

As described in the second paragraph of "STEP 9", 2 x 1.5V cells are used to test the operation of the DC fault protection circuitry on the Loudspeaker Protection module. However, the negative speaker lead from the amplifier must remain connected to the Loudspeaker Protection module during the test.

Without this connection, there is no earth return path back to the power supply, so the protection circuit will be inoperative.

Note that is still important to disconnect the positive lead from the amplifier during this test. As one hapless constructor discovered, if the positive lead is left connected and power is accidentally left on, connecting the battery will instantly destroy one of more of the amplifier's output transistors, along with their associated emitter resistors!

Studio Series Remote Control, April 2006: after power up, channel selection via the optional front-panel switches is not possible until after one channel change has been made via infrared remote. An update to the AT90S2313 microcontroller firmware is available from our website to correct this problem.

Constructors of the Studio Series Preamplifier kit do not need this update as channel selection switches were not part of the design.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine. Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

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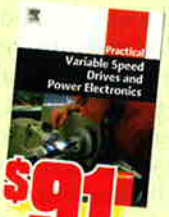

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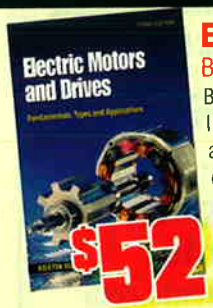

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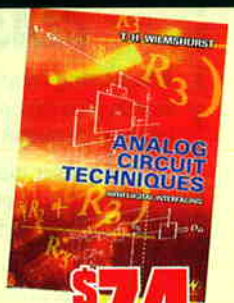

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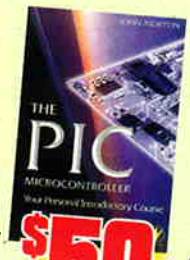

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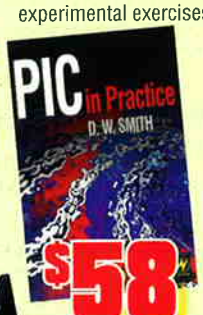

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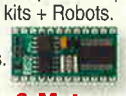

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